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Lake City, UT 84108 (US). STORJOHANN, Laura; 48  
West Broadway, #309 N, Salt Lake City, UT 84101 (US).

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(74) Agent: GIDDINGS, Barton; Madson & Metcalf, 15 West  
South Temple, Suite 900, Salt Lake City, UT 84101 (US).

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(71) Applicant: NPS PHARMACEUTICALS, INC.  
[US/US]; 420 Chipeta Way, Suite 240, Salt Lake City, UT  
84108 (US).

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(72) Inventors: KRAPCHO, Karen; NPS Pharmaceuticals,  
Inc., 420 Chipeta Way, Suite 240, Salt Lake City, UT  
84108 (US). STORMANN, Thomas; NPS Pharmaceu-  
ticals, Inc., 420 Chipeta Way, Suite 240, Salt Lake City,  
UT 84108 (US). LEVINTHAL, Cynthia; NPS Pharma-  
ceuticals, Inc., 420 Chipeta Way, Suite 240, Salt Lake  
City, UT 84108 (US). HAMMERLAND, Lance; NPS  
Pharmaceuticals, Inc., 420 Chipeta Way, Suite 240, Salt

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(54) Title: A NOVEL HUMAN METABOTROPIC GLUTAMATE RECEPTOR

(57) Abstract: A novel human metabotropic glutamate receptor (mGluR) protein is identified, sequenced, and cloned. The receptor may be used to screen for compounds that modulate the activity of the mGluR. The recombinant mGluR as well as compounds that modulate mGluR activity may be used in the diagnosis and treatment of neurological disorders and diseases.

## A NOVEL HUMAN METABOTROPIC GLUTAMATE RECEPTOR

### 1. FIELD OF THE INVENTION

The present invention relates to nucleic acid sequences coding for a newly identified splice variant of human metabotropic glutamate receptor 5 (mGluR5). The novel human receptor may be expressed in host cells which may be used to screen for agonist, antagonist, and modulatory molecules that act on the novel human mGluR5. These molecules acting on the novel human mGluR can be used to modulate the activity of the novel human receptor for the treatment of neurological disorders and diseases.

The invention also relates to nucleic acids encoding such receptors, genetically modified cells containing such nucleic acids, methods of screening for compounds that bind to or modulate the activity of such receptors, and methods of use relating to all of the foregoing.

### 2. BACKGROUND OF THE INVENTION

The following description provides a summary of information related to the background of the present invention. It is not an admission that any of the information provided herein is prior art to the presently claimed invention, nor that any of the publications specifically or implicitly referenced are prior art to that invention.

Glutamate is the major excitatory neurotransmitter in the mammalian central nervous system (CNS). Glutamate produces its effects on central neurons by binding to and thereby activating cell surface receptors. These receptors have been subdivided into two major classes, the ionotropic and metabotropic glutamate receptors, based on the structural features of the receptor proteins, the means by which the receptors transduce signals into the cell, and pharmacological profiles.

The ionotropic glutamate receptors (iGluRs) are ligand-gated ion channels that, upon binding glutamate, open to allow the selective influx of certain monovalent and divalent cations, thereby depolarizing the cell membrane. In addition, certain iGluRs with relatively high calcium permeability can activate a variety of calcium-dependent intracellular processes. These receptors are multisubunit protein complexes that may be homomeric or heteromeric in nature. The various iGluR subunits all share common structural motifs, including a relatively large amino-terminal extracellular domain (ECD), followed by two transmembrane domains (TMD), a second smaller extracellular domain, and a third TMD, before terminating with an intracellular carboxy-

terminal domain. Historically the iGluRs were first subdivided pharmacologically into three classes based on preferential activation by the agonists  $\alpha$ -amino-3-hydroxy-5-methylisoxazole-4-propionic acid (AMPA), kainate (KA), and N-methyl-D-aspartate (NMDA). Later, molecular cloning studies coupled with additional pharmacological studies revealed a greater diversity of iGluRs, in that multiple subtypes of AMPA, KA and NMDA receptors are expressed in the mammalian CNS Hollman & Heinemann (1994), *Ann. Rev. Neurosci.* 17:31.

The metabotropic glutamate receptors (mGluRs) are G-protein-coupled receptors capable of activating a variety of intracellular second messenger systems following the binding of glutamate. Activation of mGluRs in intact mammalian neurons can elicit one or more of the following responses: activation of phospholipase C, increases in phosphoinositide (PI) hydrolysis, intracellular calcium release, activation of phospholipase D, activation or inhibition of adenylyl cyclase, increases or decreases in the formation of cyclic adenosine monophosphate (cAMP), activation of guanylyl cyclase, increases in the formation of cyclic guanosine monophosphate (cGMP), activation of phospholipase A<sub>2</sub>, increases in arachidonic acid release, and increases or decreases in the activity of ion channels (e.g., voltage- and ligand-gated ion channels). Schoepp & Conn (1993), *Trends Pharmacol. Sci.* 14:13; Schoepp (1994), *Neurochem. Int.* 24:439; Pin & Duvoisin (1995), *Neuropharmacology* 34:1.

Thus far, eight distinct mGluR subtypes have been isolated via molecular cloning, and named mGluR1 to mGluR8 according to the order in which they were discovered. Nakanishi (1994), *Neuron* 13:1031; Pin & Duvoisin (1995), *Neuropharmacology* 34:1; Knopfel et al. (1995), *J. Med. Chem.* 38:1417. Further diversity occurs through the expression of alternatively spliced forms of certain mGluR subtypes. Pin et al. (1992), *Proc. Natl. Acad. Sci. USA* 89:10331; Minakami et al. (1994), *BBRC* 199:1136; Joly et al. (1995), *J. Neurosci.* 15:3970. All of the mGluRs are structurally similar, in that they are single subunit membrane proteins possessing a large amino-terminal ECD, followed by seven putative TMDs, and an intracellular carboxy-terminal domain of variable length.

The eight mGluRs have been subdivided into three groups based on amino acid sequence homologies, the second messenger systems they utilize, and pharmacological characteristics. Nakanishi (1994), *Neuron* 13:1031; Pin & Duvoisin (1995), *Neuropharmacology* 34:1; Knopfel et al. (1995), *J. Med. Chem.* 38:1417. The amino acid homology between mGluRs within a given group is approximately 70%, but drops to about 40% between mGluRs in different groups.

For mGluRs in the same group, this relatedness is roughly paralleled by similarities in signal transduction mechanisms and pharmacological characteristics.

5 The Group I mGluRs comprise mGluR1, mGluR5, and their alternatively spliced variants. The binding of agonists to these receptors results in the activation of phospholipase C and the subsequent mobilization of intracellular calcium. For example, *Xenopus* oocytes  
expressing recombinant mGluR1 receptors have been utilized to demonstrate this effect indirectly by electrophysiological means. Masu et al. (1991), *Nature* 349:760; Pin et al. (1992),  
10 *Proc. Natl. Acad. Sci. USA* 89:10331. Similar results were achieved with oocytes expressing recombinant mGluR5 receptors. Abe et al. (1992), *J. Biol. Chem.* 267:13361; Minakami et al. (1994), *BBRC* 199:1136; Joly et al. (1995), *J. Neurosci.* 15:3970. Alternatively, agonist activation of recombinant mGluR1 receptors expressed in Chinese hamster ovary (CHO) cells stimulated PI hydrolysis, cAMP formation, and arachidonic acid release as measured by standard biochemical assays. Aramori & Nakanishi (1992), *Neuron* 8:757. In comparison, activation of mGluR5 receptors expressed in CHO cells stimulated PI hydrolysis and subsequent intracellular calcium transients, but no stimulation of cAMP formation or arachidonic acid release was  
15 observed. Abe et al. (1992), *J. Biol. Chem.* 267:13361. However, activation of mGluR5 receptors expressed in LLC-PK1 cells does result in increased cAMP formation as well as PI hydrolysis. Joly et al. (1995), *J. Neurosci.* 15:3970. The agonist potency profile for Group I mGluRs is quisqualate > glutamate = ibotenate > (2S,1'S,2'S)-2-carboxycyclopropylglycine (L-CCG-I) > (1S,3R)-1-aminocyclopentane-1,3-dicarboxylic acid (ACPD). Quisqualate is relatively selective for Group I receptors, as compared to Group II and Group III mGluRs, but it also  
20 potently activates ionotropic AMPA receptors. Pin & Duvoisin (1995), *Neuropharmacology* 34:1; Knopfel et al. (1995), *J. Med. Chem.* 38:1417.

The Group II mGluRs include mGluR2 and mGluR3. Activation of these receptors as  
25 expressed in CHO cells inhibits adenyl cyclase activity via the inhibitory G protein, G<sub>i</sub>, in a pertussis toxin-sensitive fashion. Tanabe et al. (1992), *Neuron* 8:169; Tanabe et al. (1993), *J. Neurosci.* 13:1372. The agonist potency profile for Group II receptors is L-CCG-I > glutamate > ACPD > ibotenate > quisqualate. Preliminary studies suggest that L-CCG-I and (2S,1'R,2'R,3'R)-2-(2,3-dicarboxycyclopropyl)glycine (DCG-IV) are both relatively selective agonists for  
30 the Group II receptors versus other mGluRs (Knopfel et al. (1995), *J. Med. Chem.* 38:1417), but DCG-IV does exhibit agonist activity at iGluRs as well (Ishida et al. (1993), *Br. J. Pharmacol.* 109:1169).



The Group III mGluRs include mGluR4, mGluR6, mGluR7 and mGluR8. Like the Group II receptors, these mGluRs are negatively coupled to adenylyl cyclase to inhibit intracellular cAMP accumulation in a pertussis toxin-sensitive fashion when expressed in CHO cells. Tanabe et al. (1993), *J. Neurosci.* 13:1372; Nakajima et al. (1993), *J. Biol. Chem.* 268:11868; Okamoto et al. (1994), *J. Biol. Chem.* 269: 1231; Duvoisin et al. (1995), *J. Neurosci.* 15:3075. As a group, their agonist potency profile is (S)-2-amino-4-phosphonobutyric acid (L-AP4) > glutamate > ACPD > quisqualate, but mGluR8 may differ slightly with glutamate being more potent than L-AP4. Knopfel et al. (1995), *J. Med. Chem.* 38:1417; Duvoisin et al. (1995), *J. Neurosci.* 15:3075. Both L-AP4 and (S)-serine-O-phosphate (L-SOP) are relatively selective agonists for the Group III receptors.

Finally, the eight mGluR subtypes have unique patterns of expression within the mammalian CNS that in many instances are overlapping. Masu et al. (1991), *Nature* 349:760; Martin et al. (1992), *Neuron* 9:259; Ohishi et al. (1993), *Neurosci.* 53:1009; Tanabe et al. (1993), *J. Neurosci.* 13:1372; Ohishi et al. (1994), *Neuron* 13:55; Abe et al. (1992), *J. Biol. Chem.* 267:13361; Nakajima et al. (1993), *J. Biol. Chem.* 268:11868; Okamoto et al. (1994), *J. Biol. Chem.* 269:1231; Duvoisin et al. (1995), *J. Neurosci.* 15:3075. As a result, certain neurons may express only one particular mGluR subtype, while other neurons may express multiple subtypes that may be localized to similar and/or different locations on the cell (e.g., postsynaptic dendrites and/or cell bodies versus presynaptic axon terminals). Therefore, the functional consequences of mGluR activation on a given neuron will depend on the particular mGluRs being expressed, the receptors' affinities for glutamate and the concentrations of glutamate the cell is exposed to, the signal transduction pathways activated by the receptors, and the locations of the receptors on the cell. A further level of complexity may be introduced by multiple interactions between mGluR-expressing neurons in a given brain region. As a result of these complexities, and the lack of subtype-specific mGluR agonists and antagonists, the roles of particular mGluRs in physiological and pathophysiological processes affecting neuronal function are not well defined. Still, work with the available agonists and antagonists has yielded some general insights about the Group I mGluRs as compared to the Group II and Group III mGluRs.

Attempts at elucidating the physiological roles of Group I mGluRs suggest that activation of these receptors elicits neuronal excitation. Various studies have demonstrated that ACPD can produce postsynaptic excitation upon application to neurons in the hippocampus, cerebral cortex, cerebellum, and thalamus as well as other brain regions. Evidence indicates that this excitation

is due to direct activation of postsynaptic mGluRs, but it has also been suggested to be mediated by activation of presynaptic mGluRs resulting in increased neurotransmitter release. Baskys (1992), *Trends Pharmacol. Sci.* **15**:92; Schoepp (1994), *Neurochem. Int.* **24**:439; Pin & Duvoisin (1995), *Neuropharmacology* **34**:1. Pharmacological experiments implicate Group I mGluRs as the mediators of this excitation. The effect of ACPD can be reproduced by low concentrations of quisqualate in the presence of iGluR antagonists (Hu & Storm (1991), *Brain Res.* **568**:339; Greene et al. (1992), *Eur. J. Pharmacol.* **226**:279), and two phenylglycine compounds known to activate mGluR1, (S)-3-hydroxyphenylglycine ((S)-3HPG) and (S)-3,5-dihydroxyphenylglycine ((S)-DHPG), also produce the excitation (Watkins & Collingridge (1994), *Trends Pharmacol. Sci.* **15**:333). In addition, the excitation can be blocked by (S)-4-carboxyphenylglycine ((S)-4CPG), (S)-4-carboxy-3-hydroxyphenylglycine ((S)-4C3HPG) and (+)-alpha-methyl-4-carboxyphenylglycine ((+)-MCPG), compounds known to be mGluR1 antagonists. Eaton et al. (1993), *Eur. J. Pharmacol.* **244**:195; Watkins & Collingridge (1994), *Trends Pharmacol. Sci.* **15**:333.

Other studies examining the physiological roles of mGluRs indicate that activation of presynaptic mGluRs can block both excitatory and inhibitory synaptic transmission by inhibiting neurotransmitter release. Pin & Duvoisin (1995), *Neuropharmacology* **34**:1. Presynaptic blockade of excitatory synaptic transmission by ACPD has been observed on neurons in the visual cortex, cerebellum, hippocampus, striatum and amygdala (Pin et al. (1993), *Curr. Drugs: Neurodegenerative Disorders* **1**:111), while similar blockade of inhibitory synaptic transmission has been demonstrated in the striatum and olfactory bulb (Calabresi et al. (1992), *Neurosci. Lett.* **139**:41; Hayashi et al. (1993), *Nature* **366**:687). Multiple pieces of evidence suggest that Group II mGluRs mediate this presynaptic inhibition. Group II mGluRs are strongly coupled to inhibition of adenylyl cyclase, like  $\alpha_2$ -adrenergic and 5HT<sub>1A</sub>-serotonergic receptors which are known to mediate presynaptic inhibition of neurotransmitter release in other neurons. The inhibitory effects of ACPD can also be mimicked by L-CCG-I and DCG-IV, which are selective agonists at Group II mGluRs. Hayashi et al. (1993), *Nature* **366**:687; Jane et al. (1994), *Br. J. Pharmacol.* **112**:809. Moreover, it has been demonstrated that activation of mGluR2 can strongly inhibit presynaptic, N-type calcium channel activity when the receptor is expressed in sympathetic neurons (Ikeda et al. (1995), *Neuron* **14**:1029), and blockade of these channels is known to inhibit neurotransmitter release. Finally, it has been observed that L-CCG-I, at concentrations selective for Group II mGluRs, inhibits the depolarization-evoked release of <sup>3</sup>H-

aspartate from rat striatal slices. Lombardi et al. (1993), *Br. J. Pharmacol.* **110**:1407. Evidence for physiological effects of Group II mGluR activation at the postsynaptic level is limited. However, one study suggests that postsynaptic actions of L-CCG-I can inhibit NMDA receptor activation in cultured mesencephalic neurons. Ambrosini et al. (1995), *Mol. Pharmacol.* **47**:1057.

Physiological studies have demonstrated that L-AP4 can also inhibit excitatory synaptic transmission on a variety of CNS neurons. Included are neurons in the cortex, hippocampus, amygdala, olfactory bulb and spinal cord. Koerner & Johnson (1992), *Excitatory Amino Acid Receptors; Design of Agonists and Antagonists*, p. 308; Pin et al. (1993), *Curr. Drugs: Neurodegenerative Disorders* **1**:111. The accumulated evidence indicates that the inhibition is mediated by activation of presynaptic mGluRs. Since the effects of L-AP4 can be mimicked by L-SOP, and these two agonists are selective for Group III mGluRs, members of this mGluR group are implicated as the mediators of the presynaptic inhibition. Schoepp (1994), *Neurochem. Int.* **24**:439; Pin & Duvoisin (1995), *Neuropharmacology* **34**:1. In olfactory bulb neurons it has been demonstrated that L-AP4 activation of mGluRs inhibits presynaptic calcium currents. Trombley & Westbrook (1992), *J. Neurosci.* **12**:2043. It is therefore likely that the mechanism of presynaptic inhibition produced by activation of Group III mGluRs is similar to that for Group II mGluRs, i.e. blockade of voltage-dependent calcium channels and inhibition of neurotransmitter release. L-AP4 is also known to act postsynaptically to hyperpolarize ON bipolar cells in the retina. It has been suggested that this action may be due to activation of a mGluR, which is coupled to the cGMP phosphodiesterase in these cells. Schoepp (1994), *Neurochem. Int.* **24**:439; Pin & Duvoisin (1995), *Neuropharmacology* **34**:1.

Metabotropic glutamate receptors have been implicated as playing roles in a number of normal processes in the mammalian CNS. Activation of mGluRs has been demonstrated to be a requirement for the induction of hippocampal long-term potentiation and cerebellar long-term depression. Bashir et al. (1993), *Nature* **363**:347; Bortolotto et al. (1994), *Nature* **368**:740; Aiba et al. (1994), *Cell* **79**:365; Aiba et al. (1994), *Cell* **79**:377. A role for mGluR activation in nociception and analgesia has also been demonstrated. Meller et al. (1993), *Neuroreport* **4**:879. In addition, mGluR activation has been suggested to play a modulatory role in a variety of other normal processes including: synaptic transmission, neuronal development, neuronal death, synaptic plasticity, spatial learning, olfactory memory, central control of cardiac activity, waking, motor control, and control of the vestibulo-ocular reflex (for reviews, see Nakanishi (1994),

*Neuron* 13: 1031; Pin & Duvoisin (1995), *Neuropharmacology* 34:1; Knopfel et al. (1995), *J. Med. Chem.* 38:1417).

From the forgoing, it will be appreciated that it would be an advancement in the art to identify and characterize novel human metabotropic glutamate receptors and the nucleic acids that code for such receptors. It would be a further advancement to provide methods for screening for agonists, antagonists, and modulatory molecules that act on such receptors.

Such receptors, nucleic acids, and methods are disclosed and claimed herein.

### 3. BRIEF SUMMARY OF THE INVENTION

The present invention relates to (1) nucleic acids encoding a newly identified splice variant of human metabotropic glutamate receptor 5 protein and fragments thereof; (2) the metabotropic glutamate receptor protein and fragments thereof; (3) chimeric receptor molecules having one or more domains derived from the new metabotropic glutamate receptor and one or more domains derived from a different receptor; (4) cell lines expressing the metabotropic glutamate receptor protein and fragments thereof; (5) uses of such molecules, nucleic acids, proteins, and cell lines; (6) methods of screening for a compound that binds to or modulates the activity of the metabotropic glutamate receptor; and (7) compounds and methods for modulating the metabotropic glutamate receptor activity and binding to the metabotropic glutamate receptor. Such compounds preferably act as agonists, antagonists, or allosteric modulators of one or more of the metabotropic glutamate receptor activities. By modulating the metabotropic glutamate receptor activities, different effects can be produced, such as anticonvulsant effects, neuroprotectant effects, analgesic effects, psychotropic effects and cognition-enhancement effects.

Metabotropic glutamate receptors have been suggested to play roles in a variety of pathophysiological processes and disease states affecting the CNS. These include stroke, head trauma, anoxic and ischemic injuries, hypoglycemia, epilepsy, anxiety, and neurodegenerative diseases such as Alzheimer's disease. Schoepp & Conn (1993), *Trends Pharmacol. Sci.* 14:13; Cunningham et al. (1994), *Life Sci.* 54:135; Hollman & Heinemann (1994), *Ann. Rev. Neurosci.* 17:31; Pin & Duvoisin (1995), *Neuropharmacology* 34:1; Knopfel et al. (1995), *J. Med. Chem.* 38:1417. Much of the pathology in these conditions is thought to be due to excessive glutamate-induced excitation of CNS neurons. Since Group I mGluRs appear to increase glutamate-mediated neuronal excitation via postsynaptic mechanisms and enhanced presynaptic glutamate

release, their activation may contribute to the pathology. Therefore, selective antagonists of these receptors could be therapeutically beneficial, specifically as neuroprotective agents or anticonvulsants. In contrast, since activation of Group II and Group III mGluRs inhibits presynaptic glutamate release and the subsequent excitatory neurotransmission, selective agonists for these receptors might exhibit similar therapeutic utilities. Thus, the various mGluR subtypes may represent novel targets for CNS drug development.

Preliminary studies assessing therapeutic potentials with the available mGluR agonists and antagonists have yielded seemingly contradictory results. For example, it has been reported that application of ACPD onto hippocampal neurons leads to seizures and neuronal damage. Sacaan & Schoepp (1992), *Neurosci. Lett.* **139**:77; Lipparti et al. (1993), *Life Sci.* **52**:85. But, other studies indicate that ACPD can inhibit epileptiform activity (Taschenberger et al. (1992), *Neuroreport* **3**:629; Sheardown (1992), *Neuroreport* **3**:916), and can also exhibit neuroprotective properties (Koh et al. (1991), *Proc. Natl. Acad. Sci. USA* **88**:9431; Chiamulera et al. (1992), *Eur. J. Pharmacol.* **216**:335; Siliprandi et al. (1992), *Eur. J. Pharmacol.* **219**:173; Pizzi et al. (1993), *J. Neurochem.* **61**:683). It is likely that these opposing results are due to ACPD's lack of selectivity and activation of different mGluR subtypes. A reasonable explanation for the results is that Group I mGluRs were activated in the former studies to enhance excitatory neurotransmission, while the latter effects were mediated by activation of Group II and/or Group III mGluRs to inhibit presynaptic glutamate release, and diminish excitatory neurotransmission. The observations that (S)-4C3HPG, a Group I mGluR antagonist and Group II mGluR agonist, protects against audiogenic seizures in DBA/2 mice (Thomsen et al. (1994), *J. Neurochem.* **62**:2492); while the Group II mGluR selective agonists DCG-IV and L-CCG-I protect neurons from NMDA- and KA-induced toxicity (Bruno et al. (1994), *Eur. J. Pharmacol.* **256**:109; Pizzi et al., *J. Neurochem.* **61**:683) are also consistent with this interpretation.

It is evident that the currently available mGluR agonists and antagonists may be of limited use, both as research tools and potential therapeutic agents, as a result of their lack of potency and selectivity. In addition, since these compounds are for the most part amino acids or amino acid derivatives, they have limited bioavailabilities, which hampers *in vivo* studies assessing mGluR physiology, pharmacology and therapeutic potential. The identification of agonists and antagonists with a high degree of potency and selectivity for individual mGluR subtypes is therefore the most important requirement to increase the understanding of various mGluRs' roles in physiological and pathophysiological processes in the mammalian CNS. High-

throughput screening of chemical libraries using cells stably transfected with individual, cloned mGluRs may offer a promising approach to identify new lead compounds which are active on the individual receptor subtypes. Knopfel et al. (1995), *J. Med. Chem.* **38**:1417. These lead compounds could serve as templates for extensive chemical modification studies to further improve potency, mGluR subtype selectivity, and important therapeutic characteristics such as bioavailability.

The preferred use of the receptor and methods of the present invention is to screen for compounds which modulate the activity of the novel metabotropic glutamate receptor. However, other uses are also contemplated, including diagnosis and treatment. Such uses are based on the novel metabotropic glutamate receptor identified herein, the amino acid sequence of which is provided in SEQ ID NO: 2, and the DNA coding sequence is provided in SEQ ID NO: 1 (representing the open reading frame (ORF) of human mGluR5d, nucleotides 1-2826).

Thus, in a first aspect, the invention provides a purified or isolated nucleic acid molecule at least 15 nucleotides in length. This nucleic acid codes for at least five contiguous amino acid residues of a unique portion of a metabotropic glutamate receptor protein which has the amino acid sequence provided in SEQ ID NO: 2, a metabotropic glutamate receptor protein which is a contiguous portion of SEQ ID NO: 2, or a functional equivalent of such amino acid sequences. Preferably, the metabotropic glutamate receptor protein is a human protein. In particular embodiments the nucleic acid molecule comprises a genomic DNA sequence, a cDNA sequence, or an RNA sequence. In preferred embodiments, the glutamate receptor protein comprises SEQ ID NO: 2 or a functional equivalent of that sequence. In certain other embodiments, the glutamate receptor protein comprises residues 861 to 942 of the amino acid sequence of SEQ ID NO: 2; these residues form the unique cytoplasmic tail of mGluR5d. Of particular interest are nucleic acid molecules encoding essentially a full size novel metabotropic glutamate receptor protein. Therefore, in preferred embodiments the nucleic acid molecule encodes the amino acid sequence of SEQ ID NO: 2, or of amino acid residues of 861 to 942 of SEQ ID NO: 2, or of a functional equivalent of those sequences.

It is recognized that a large yet finite number of different nucleic acid sequences will code for the same amino acid sequence due to the redundancy of the genetic code. Such alternative coding sequences are within the scope of the above aspect of the invention.

In a preferred embodiment, the nucleic acid molecule encoding the amino acid sequence of SEQ ID NO: 2 has the nucleic acid sequence of SEQ ID NO: 1. Also in preferred

embodiments, the nucleic acid molecule comprises at least 15 or 50 contiguous nucleotides of the nucleic acid sequence SEQ ID NO: 1 or of a sequence substantially complementary thereto.

Since the use of a modified metabotropic glutamate receptor protein is advantageous in certain applications, in a preferred embodiment, the invention also provides an isolated or  
5 purified nucleic acid molecule encoding an amino acid sequence which comprises an extracellular domain which is part of the amino acid sequence of SEQ ID NO: 2. In this embodiment the encoded amino acid sequence is substantially free of membrane spanning domain and intracellular domain portions contained in the amino acid sequence of SEQ ID NO: 2. Likewise, in other particular embodiments, the invention provides other isolated or purified  
10 nucleic acid molecules encoding one or more domains which are part of the amino acid sequence of SEQ ID NO: 2, but which do not include at least one such domain. Thus, the invention provides nucleic acid molecules which encode an intracellular domain that is free of transmembrane and extracellular domains, or a transmembrane domain that is free of intracellular and extracellular domains, or an extracellular domain of a metabotropic glutamate receptor that  
15 is substantially free of the membrane spanning domains of said metabotropic glutamate receptor, or extracellular and membrane spanning domains which are substantially free of the intracellular domain. Similarly, in particular embodiments, the nucleic acid encodes a metabotropic glutamate receptor that is substantially free of at least one membrane spanning domain portion or a metabotropic glutamate receptor that is substantially free of the extracellular domain of said  
20 metabotropic glutamate receptor, or a contiguous multiple-transmembrane domain including intervening intracellular and extracellular domains but substantially free of N-terminal extracellular and C-terminal intracellular domains of SEQ ID NO: 2 (e.g., a seven-transmembrane domain).

In further preferred embodiments the nucleic acid molecule encodes an extracellular  
25 domain of SEQ ID NO: 2, transcriptionally coupled to a second nucleic acid molecule which encodes transmembrane and intracellular domains of a protein which is not a metabotropic glutamate receptor protein (i.e., a non-metabotropic glutamate receptor); the purified nucleic acid encodes a fusion protein composed of an N-terminal extracellular domain contiguous with a seven-transmembrane domain of SEQ ID NO: 2 and is transcriptionally coupled to nucleic acid  
30 encoding a C-terminal intracellular domain of a non-metabotropic glutamate receptor; the purified nucleic acid encodes a fusion protein composed of an N-terminal extracellular domain contiguous with a seven-transmembrane domain of SEQ ID NO: 2 and is transcriptionally

coupled to nucleic acids encoding multiple intracellular domains of a non-metabotropic glutamate receptor.

Since it is advantageous in certain applications to utilize the complementary or anticoding DNA strand, the invention also provides an isolated or purified nucleic acid molecule which has  
5 a sequence substantially complementary to the sequence of a nucleic acid molecule of the above aspect.

In the context of this invention, the term "purified" means that the specified nucleic acid molecule or polypeptide has been separated from other nucleic acid molecules or polypeptides, respectively, with which it is found in such a manner that it forms a substantial fraction of the  
10 total nucleic acids or polypeptides present in a preparation. Preferably, the specified molecule constitutes at least 1, 5, 10, 50, 75, 85, or 95 percent or more of the molecules of that type (nucleic acid or polypeptide) present in a preparation.

By "isolated" in reference to nucleic acid, polypeptides, or other biomolecules of this invention is meant the molecule is present in a form (i.e., its association with other molecules)  
15 other than found in nature. For example, an isolated receptor nucleic acid is separated from one or more nucleic acids which are present on the same chromosome, and an isolated polypeptide is separated from a substantial fraction of the other polypeptides with which it is normally found in nature. Preferably, the isolated nucleic acid or polypeptide is separated from at least 90% of the other nucleic acids present on the same chromosome or polypeptides normally found in the  
20 same cell. An example of isolated nucleic acid is recombinant nucleic acid. In this application, the term isolated nucleic acid is distinct from clones existent in a library of clones. It refers to a particular clone having the designated material encoded therein, isolated from other such clones. It can be created by standard recombinant methods to exist within a test-tube or within a desired cell or organism. It is preferably the only nucleic acid cloned within a standard vector,  
25 and may or may not contain the naturally occurring control sequences associated with it. Thus, it contains nucleic acid isolated from its natural environment and known to have the sequence claimed to be present. It is preferably a homogenous preparation of nucleic acid separate from other cellular components and from other nucleic acids.

In referring to the nucleic acids and polypeptides of the present invention, the term  
30 "unique" refers to a difference in sequence between a nucleic acid molecule of the present invention and the corresponding sequence of other receptor proteins, including other



metabotropic glutamate receptor proteins. Thus, the sequences differ by at least one, but preferably a plurality of nucleotides or amino acid residues.

By "substantially complementary" is meant that the purified nucleic acid can hybridize to the complementary sequence region in a specific nucleic acid under stringent hybridization conditions. Such nucleic acid sequences are particularly useful as hybridization detection probes to detect the presence of nucleic acid encoding a particular receptor. Under stringent hybridization conditions, only highly complementary nucleic acid sequences hybridize. Preferably, such conditions prevent hybridization of nucleic acids having 4 or more mismatches out of 20 contiguous nucleotides, more preferably 2 or more mismatches out of 20 contiguous nucleotides, most preferably one or more mismatch out of 20 contiguous nucleotides. Preferably, the nucleic acid is substantially complementary to at least 15, 20, 27, or 45, contiguous nucleotides of the specific sequence (e.g., in SEQ ID NO: 1).

In the context of the novel receptor and fragments, the term "functional equivalent" refers to a polypeptide that has an activity that can be substituted for one or more activities of a particular receptor or receptor fragment. This is explained in greater detail in the Detailed Description below.

In reference to the different domains of a metabotropic glutamate receptor, the term "substantially free" refers to the absence of at least most of the particular domain, preferably such that essentially none of an activity of interest specific to that domain remains. Thus, a short portion(s) of the particular domain sequence may remain, but does not provide a substantial particular activity normally provided by the intact domain.

By "comprising" it is meant including, but not limited to, whatever follows the word "comprising." Thus use of the term indicates that the listed elements are required, but that other elements are optional and may or may not be present. By "consisting essentially of" is meant that the listed elements are required, but that other elements are optional and may or may not be present depending upon whether or not they affect the activity or action of the listed elements.

Isolated or purified polypeptides corresponding to the nucleic acid molecules of the above aspects are also provided by the present invention. Therefore, in another aspect the invention features a purified polypeptide having at least 6 contiguous amino acids of an amino acid sequence provided in SEQ ID NO: 2. In preferred embodiments, the purified polypeptide has at least 12, 18, or 54 contiguous amino acids of SEQ ID NO: 2. In further preferred embodiments, the purified polypeptide comprises residues 861 to 942 of the amino acid sequence

of SEQ ID NO: 2, which form the unique cytoplasmic tail of mGluR5d. Other preferred receptor fragments include those having only an extracellular portion, a transmembrane portion, an intracellular portion, and/or a multiple transmembrane portion (e.g., seven transmembrane portion). In a particularly preferred embodiment, the polypeptide comprises the amino acid sequence of SEQ ID NO: 2.

Expression of a recombinant nucleic acid encoding a metabotropic glutamate receptor or receptor fragment is a useful method of producing polypeptides such as those described above. Therefore, in another aspect, the invention provides recombinant nucleic acid encoding a metabotropic glutamate receptor or receptor fragment as described in the first aspect above (i.e., coding for a metabotropic glutamate receptor protein having the amino acid sequence SEQ ID NO: 2 or functional equivalents thereof (i.e., these having one or more of the activities associated with that protein but having a few (1-10) amino acid alterations at non-critical areas which do not affect such activities)), cloned in an expression vector. An expression vector contains the necessary elements for expressing a cloned nucleic acid sequence to produce a polypeptide. An "expression vector" contains a promoter region (which directs the initiation of RNA transcription) as well as the DNA sequences which, when transcribed into RNA, will signal protein synthesis initiation. "Expression vector" includes vectors which are capable of expressing DNA sequences contained therein, i.e., the coding sequences are operably linked to other sequences capable of effecting their expression. It is implied, although not always explicitly stated, that these expression vectors must be replicable in the host organisms, either as episomes or as an integral part of the chromosomal DNA. Clearly, a lack of replicability would render them effectively inoperable. A useful, but not a necessary, element of an effective expression vector is a marker-encoding sequence—i.e., a sequence encoding a protein which results in a phenotypic property (e.g., tetracycline resistance) of the cells containing the protein which permits those cells to be readily identified. In sum, "expression vector" is given a functional definition, and any DNA sequence which is capable of effecting expression of a specified contained DNA code is included in this term, as it is applied to the specified sequence. As such vectors are at present frequently in the form of plasmids, the terms "plasmid" and "expression vector" are often used interchangeably. However, the invention is intended to include such other forms of expression vectors, including viral vectors, which serve equivalent functions and which may, from time to time become known in the art.

In reference to receptor proteins, "biologically functional" and "functional receptor" indicate that the receptor molecule or portion has a normal biological activity characteristic of the normal receptor in its usual cellular environment, which is relevant in the process of interest. Such a process can be, for example, a binding assay, or a complex cellular response. Preferably, a functional receptor is capable of participating in the normal cellular response reactions. In reference to an expression vector, "biologically functional" means that the expression vector can be transcribed and the transcription product translated in the cell or expression system of interest.

The terms "transformed" and "transfected" refer to the insertion of a foreign genetic material into a prokaryotic or eukaryotic cell. Such insertion is commonly performed using vectors, such as plasmid or viral vectors, but can also include other techniques known to those skilled in the art.

Recombinant nucleic acid may contain nucleic acid encoding a metabotropic glutamate receptor, receptor fragment, or metabotropic glutamate receptor derivative, under the control of its genomic regulatory elements or under the control of exogenous regulatory elements, including an exogenous promoter. By "exogenous" is meant a promoter that is not normally coupled *in vivo* transcriptionally to the coding sequence for the metabotropic glutamate receptor.

The expression vector may be used in another aspect of the invention to transform or transfect a prokaryotic or a eukaryotic host cell. Thus, another aspect of the present invention features a recombinant cell or tissue. The recombinant cell or tissue is made up of a recombinant nucleic acid sequence of the first aspect above, and a cell able to express the nucleic acid. Recombinant cells have various uses, including as biological factories to produce polypeptides encoded for by the recombinant nucleic acid, and for producing cells containing a functioning metabotropic glutamate receptor. Cells containing a functioning metabotropic glutamate receptor can be used, for example, to screen for mGluR agonists, antagonists, or allosteric modulators. In preferred embodiments, the cell containing the recombinant nucleic acid encoding a functioning metabotropic glutamate receptor is selected from the group consisting of: central nervous system cell, peripheral nervous system cell, pituitary cell, and hypothalamic cell; and the recombinant nucleic acid encodes at least 12, 18 or 54 contiguous amino acids of SEQ ID NO: 2. In a particular embodiment of the invention the host cell is an oocyte, for example a *Xenopus* oocyte. In other preferred embodiments, the cell is one of NIH-3T3, HeLa, NG115, CHO, HEK 293 and COS7.

Another aspect of the invention describes a process for the production of a polypeptide product involving growing prokaryotic or eukaryotic host cells transformed or transfected with an expression vector having a nucleic acid molecule which codes for a metabotropic glutamate receptor protein having the amino acid sequence SEQ ID NO: 2, or a portion of that sequence, or a functional equivalent, under suitable nutrient conditions. The host cells are grown in a manner allowing expression of the polypeptide product. In a preferred aspect of the invention the process further involves isolation of the polypeptide product. "Suitable nutrient conditions" are those which will allow a cell to carry on normal metabolic functions and/or grow. The conditions suitable for a particular cell line or strain will generally differ, but appropriate conditions for each such cell type are known to or can be determined by methods known to those skilled in the art.

Another aspect of the invention features a method of screening for a compound that binds to or modulates the activity of a metabotropic glutamate receptor having the sequence SEQ ID NO: 2. The method involves introducing the metabotropic glutamate receptor and a test compound into an acceptable medium and monitoring the binding or modulation by physically detectable means, thereby identifying the compounds which interact with or modulate the activity of the metabotropic glutamate receptor. Such a compound is useful as a therapeutic molecule to modulate metabotropic glutamate receptor activity or as a diagnostic agent to diagnose patients suffering from a disease characterized by an abnormal metabotropic glutamate activity. In a preferred embodiment, the mGluR is a chimeric receptor having an extracellular domain contained in the amino acid sequence of SEQ ID NO: 2 and an intracellular domain of a different receptor. Such a chimeric receptor allows activation of a cellular pathway not normally activated by the novel mGluR described herein. Also, in a preferred embodiment the metabotropic glutamate receptor is expressed by a cell and the compound is screened by monitoring the effect of the compound on the cell. More preferably, the cell is a eukaryotic cell. For example, the method can involve contacting a cell containing a recombinant nucleic acid encoding a metabotropic glutamate receptor with the agent and detecting a change in metabotropic glutamate receptor activity. In another preferred embodiment, the method involves a competition binding assay with a labeled known binding agent. Preferably, the method is used to identify a metabotropic glutamate receptor-modulating agent.

The term "physically detectable means" refers herein to the means for detecting the interaction between a modulator or binding compound and the novel metabotropic glutamate

receptor molecule. Such means can include, for example, spectroscopic methods (e.g., fluorometric measurement of  $\text{Ca}^{2+}$ ), electrophysiological assays, and biochemical assays (e.g., specific enzyme activity). In addition to a variety of other assays, such biochemical assay can include detection of the activation by a chimeric receptor of a cellular pathway not normally  
5 activated by the novel mGluR. Each technique detects a physical property or parameter.

A "chimeric receptor" is one which has an amino acid sequence which is a fusion or association of sequences from two or more different proteins, at least one of which is a receptor protein. Typically in this invention, a chimeric receptor has amino acid sequences constituting domains (such as extracellular, membrane spanning, and intracellular) from two or more different  
10 receptor proteins, one of which is the novel mGluR5d of this invention.

Identification of metabotropic glutamate receptor-modulating agents is facilitated by using a high-throughput screening system. High-throughput screening allows a large number of molecules to be tested. For example, a large number of molecules can be tested individually using rapid automated techniques or in combination with using a combinatorial library of  
15 molecules. Individual compounds able to modulate metabotropic glutamate receptor activity present in a combinatorial library can be obtained by purifying and retesting fractions of the combinatorial library. Thus, thousands to millions of molecules can be screened in a short period of time. Active molecules can be used as models to design additional molecules having equivalent or increased activity. Such molecules will generally have a molecular weight of  
20 10,000, preferably less than 1,000.

A further aspect of the present invention describes a method of modulating the activity of a metabotropic glutamate receptor having the amino acid sequence of SEQ ID NO: 2, or a portion, or a functional equivalent, and includes the step of contacting the receptor with a compound that modulates one or more activities of the metabotropic glutamate receptor, in  
25 general either activating or inhibiting activation of the receptor.

The metabotropic glutamate receptor is contacted with a sufficient amount of a compound to modulate a metabotropic glutamate receptor activity. Modulating metabotropic glutamate receptor activity causes an increase or decrease in a cellular response which occurs upon metabotropic glutamate receptor activation, as described in the Detailed Description below.  
30 Typically, the compound either mimics one or more effects of glutamate at the metabotropic glutamate receptor, or blocks one or more effects of glutamate at the metabotropic glutamate receptor (or potentially both). The method can be carried out *in vitro* or *in vivo*.

The term "mimics" means that the compound causes a similar effect to be exhibited as is exhibited in response to contacting the receptor with glutamate. "Blocks" means that the presence of the compound prevents one or more of the normal effects of contacting the receptor with glutamate.

5 In the context of this invention, "*in vitro*" means that a process is not carried out within or by a living cell(s). However, the process may use cell membranes and other cell parts, or even complete but non-living cells. "*In vivo*" means that the process is carried out within or by a living cell(s), and thus includes processes carried out within or by complex organisms such as mammals.

10 With respect to a metabotropic glutamate receptor, "functioning" or "functional" indicates that the receptor has at least some of the relevant biological activities which such a receptor has under normal biological conditions (normal receptor under normal cellular conditions), and preferably substantially all of such activities. These can include, for example, specific binding characteristics and specific enzymatic activity (among others).

15 Related aspects of the present invention describe agents (e.g., compounds and pharmaceutical compositions) able to bind to the metabotropic glutamate receptor having the amino acid sequence SEQ ID NO: 2, or a portion or functional equivalent thereof. Preferably, the agent can modulate metabotropic glutamate receptor activity.

20 Other features and advantages of the invention will be apparent from the following description of the preferred embodiments thereof, and from the claims.

#### 4. BRIEF DESCRIPTION OF THE DRAWINGS

25 A more particular description of the invention briefly described above will be rendered by reference to the appended drawings and graphs. These drawings and graphs only provide information concerning typical embodiments of the invention and are not therefore to be considered limiting of its scope.

Figure 1A shows the amino acid sequence of the 3' end of human mGluR5d (amino acids 803 to 942 of SEQ ID NO: 2).

30 Figure 1B shows the amino acid sequence of human mGluR5b (amino acids 896 to 1165 of SEQ ID NO: 7) that is deleted from human mGluR5d. The two starred serine residues correspond to serines at positions 881 and 890 of rat mGluR5a. Gereau & Heineman (1998), *Neuron* 20:143.

Figure 2 is a graph depicting the agonist pharmacology of human mGluR5d expressed in HEK293 cells.

Figure 3 is a graph depicting the reduced rapid desensitization properties of human mGluR5d expressed in *Xenopus* oocytes.

5        Figure 4 illustrates functional activation of the hmGluR5d receptor expressed in HEK293 cells with the agonist DHPG.

Figure 5 illustrates functional activation of the hCaR/hmGluR5d chimeric receptor expressed in HEK293 cells by calcium as agonist.

10        5.        DETAILED DESCRIPTION OF THE INVENTION

The cloning of eight metabotropic glutamate receptor subtypes from rat or mouse has been reported in the scientific literature. These include: rat mGluR1 (Masu et al. (1991), *Nature* 349:760; Houamed et al. (1991), *Science* 252:1318; Pin et al. (1992), *Proc. Natl. Acad. Sci. USA* 89:10331), rat mGluR2 (Tanabe et al. (1992), *Neuron* 8:169), rat mGluR3 (Tanabe et al. (1992), *Neuron* 8:169), rat mGluR4 (Tanabe et al. (1992), *Neuron* 8:169), rat mGluR5 (Abe et al. (1992), *J. Biol. Chem.* 267:13361), rat mGluR6 (Nakajima et al. (1993), *J. Biol. Chem.* 268:11868), rat mGluR7 (Okamoto et al. (1994), *J. Biol. Chem.* 269:1231; Saugstad et al. (1994), *Mol. Pharmacol.* 45:367) and mouse mGluR8 (Duvoisin et al. (1995), *J. Neuroscience* 15:3075). The cloning of the human metabotropic glutamate receptor subtypes mGluR1 (Lin et al. (1994), *Soc. Neurosci. Abstr.* 20:468), mGluR2 (Flor et al. (in press), *Eur. J. Neurosci.*; Knopfel et al. (1995), *J. Med. Chem.* 38:1417), mGluR4 (Flor et al. (1994), *Neuropharmacol.* 34:149), mGluR5 (Minakami et al. (1994), *Biochem. Biophys. Res. Commun.* 199:1136) and mGluR7 (Flor et al. (1994), *Soc. Neurosci. Abstr.* 20:468) have also been reported.

25        U.S. Patent No. 5,385,831 provides G-protein-coupled glutamate receptors isolated and cloned from rats. U.S. Patent No. 5,521,297 provides a human metabotropic glutamate receptor and related DNA compounds described by the applicants as a human mGluR1. The subject of the present invention is a novel human metabotropic glutamate receptor. The novel receptor of the present invention is a human metabotropic glutamate receptor that is related to the Group I metabotropic glutamate receptors, which include mGluR1 and mGluR5.

30        The Applicants are the first to demonstrate the novel human metabotropic glutamate receptor of the present invention, as well as the first to determine the nucleic acid sequence.

## 5.1 Techniques

### 5.1.1 Novel mGluR Nucleic Acid Sequence

The invention features nucleic acid sequences encoding metabotropic glutamate receptors and receptor fragments. The nucleic acid sequences may be engineered so as to allow for  
5 expression of the receptor sequences in prokaryotic or eukaryotic cells. For example, the entire coding sequence or a fragment thereof, may be combined with one or more of the following in an appropriate expression vector to allow for such expression: (1) an exogenous promoter sequence, (2) a ribosome binding site, (3) a polyadenylation signal, and (4) a secretion signal. Modification can be made in the 5'-untranslated sequences to improve expression in a  
10 prokaryotic or eukaryotic cell, or codons may be modified such that while they encode an identical amino acid, that codon may be a preferred codon in the chosen expression system. The use of such preferred codons is described in, for example, Grantham et al. (1981), *Nuc. Acids Res.*, 9:43-74, and Lathe (1985), *J. Mol. Biol.*, 183:1-12. In a preferred embodiment of the current invention, the nucleic acid sequence is that of SEQ ID NO: 1, encoding a novel human  
15 metabotropic glutamate receptor.

In addition, a nucleic acid sequence encoding a particular receptor provides for additional tools to obtain other related receptors, for example by providing for nucleic acid hybridization assay probes. Furthermore, the nucleic acid sequences encoding two or more different but related receptors can be analyzed to determine localized regions of sequence conservation. These  
20 conserved nucleic acid regions are useful as hybridization probes, or alternatively provide for the design and synthesis of hybridization probes, which can be used to obtain cloned nucleic acids encoding other members of a receptor superfamily. Conserved sequences may be deduced from an analysis of the entire nucleic acid sequence of SEQ ID NO: 1 and comparison of that sequence with the nucleotide sequences encoding other mGluRs.

25 "Conserved nucleic acid regions" refers to regions within two or more nucleic acids encoding metabotropic glutamate receptors, to which a particular complementary nucleic acid can hybridize under lower stringency conditions. Examples of lower stringency conditions suitable for screening for nucleic acids encoding metabotropic glutamate receptors are provided in the examples below and in Abe et al. (1992), *J. Biol. Chem.* 19:13361. Preferably, conserved  
30 nucleic acid regions differ by no more than 7 out of 20 nucleotides.

Uses of nucleic acids encoding cloned receptors or receptor fragments include one or more of the following: (1) producing receptor proteins which can be used, for example, for



structure determination, to assay a molecule's activity on a receptor; (2) being sequenced to determine a receptor's nucleotide sequence which can be used, for example, as a basis for comparison with other receptors to determine conserved regions, determine unique nucleotide sequences for normal and altered receptors, and to determine nucleotide sequences to be used as target sites for hybridization detection probes or polymerase chain reaction (PCR) amplification primers; (3) as hybridization detection probes to detect the presence of a native receptor and/or a related receptor in a sample; and (4) as PCR primers to generate particular nucleic acid sequence regions, for example to generate regions to be probed by hybridization detection probes.

In general, the nucleic acid molecules of this invention have nucleic acid sequences encoding full length metabotropic glutamate receptors, metabotropic glutamate receptor fragments, derivatives of full length metabotropic glutamate receptors, and derivatives of metabotropic glutamate receptor fragments useful in the present invention. These include nucleic acid sequences comprising the sequence provided in SEQ ID NO: 1 or nucleic acid sequences which encode the protein sequence provided in SEQ ID NO: 2, or their complementary strands; nucleic acid sequences which hybridize under stringent conditions to the nucleic acid sequence SEQ ID NO: 1 or to fragments thereof; and nucleic acid sequences which, but for the degeneracy of the genetic code would hybridize to the nucleic acid sequence SEQ ID NO:1.

Preferably, the nucleic acid contains at least 15, 18, 27, and most preferably at least 45, contiguous nucleic acids of a sequence provided in SEQ ID NO: 1. Advantages of longer-length nucleic acid include producing longer-length protein fragments having the sequence of a metabotropic glutamate receptor which can be used, for example, to produce antibodies; increased nucleic acid probe specificity under higher stringency hybridization assay conditions; and more specificity for related metabotropic glutamate receptor nucleic acid under lower stringency hybridization assay conditions.

The present invention also features an isolated and purified nucleic acid which codes for residues 861 to 942 of the amino acid sequence of SEQ ID NO: 2.

Similarly the present invention features nucleic acid encoding a metabotropic glutamate receptor or fragment thereof comprising a nucleic acid sequence encoding at least five contiguous amino acids provided in SEQ ID NO: 2. Preferably, the nucleic acid encodes at least 12, 18, 30, or 54 contiguous amino acids of SEQ ID NO: 2. In certain embodiments, the nucleic acid

encodes at least one contiguous, more preferably at least three, six, nine, 12, or 15 contiguous amino acids provided in residues 861 to 942 of SEQ ID NO: 2.

Further, the nucleic acid may be complementary to the nucleic acid sequence coding for either the extracellular binding domain, the transmembrane domain or the intracellular domain portions. The nucleic acid coding for such domains may be transcriptionally coupled to a second nucleic acid sequence from a non-metabotropic glutamate receptor protein. For example, nucleic acid sequence derived from the novel receptor disclosed herein coding for the extracellular domain can be transcriptionally coupled to a second nucleic acid encoding the transmembrane and intracellular coding domain of a non-metabotropic glutamate receptor, or an extracellular binding domain can be transcriptionally coupled to a second nucleic acid encoding the transmembrane and intracellular coding domain of a metabotropic glutamate receptor that is a member of a different class or subclass of mGluR than the receptor having the sequence SEQ ID NO: 2. Such nucleic acids coding for receptor fragments and chimeric receptors are described in, for example, U.S. Patent No. 5,981,195. Due to the degeneracy of the genetic code, different combinations of nucleotides can code for the same polypeptide. Thus, numerous metabotropic glutamate receptors and receptor fragments having the same amino acid sequences can be encoded for by different nucleic acid sequences.

#### 5.1.1.1 Cloning Using Hybridization Probes and Primers

The presently preferred method for isolating mGluR nucleic acid is based upon hybridization screening. Region-specific primers or probes derived from nucleic acid encoding a metabotropic glutamate receptor such as the nucleic acid sequence SEQ ID NO: 1, or a nucleic acid encoding the amino acid sequence SEQ ID NO: 2, can be used to prime DNA synthesis and PCR amplification, as well as to identify bacterial colonies or phage plaques containing cloned DNA encoding a member of the mGluR family using known methods. *See, e.g., Innis et al. (1990), PCR Protocols* (Academic Press, San Diego, CA); Sambrook et al. (1989), *Molecular Cloning* (Cold Spring Harbor Laboratory Press).

##### 5.1.1.1.1 PCR Cloning

Primer hybridization specificity to target nucleic acid encoding a mGluR can be adjusted by varying the hybridization conditions. When carrying out hybridization at higher stringency conditions of 50-60°C, sequences which are greater than about 76% homologous to the primer will be amplified. When employing lower stringency conditions, by carrying out hybridization

at 35-37°C, sequences which are greater than about 40-50% homologous to the primer will be amplified.

Analysis of metabotropic glutamate receptors indicates that they are G-protein-coupled receptors having seven conserved, putative transmembrane domains. One particularly useful approach is to employ degenerate primers homologous to the conserved, putative transmembrane domains and to amplify DNA regions encoding these sequences using polymerase chain reaction (PCR). Thus, such oligonucleotide primers are mixed with genomic DNA or cDNA prepared from RNA isolated from the tissue of choice and PCR carried out. Some experimentation may be required to specifically amplify novel G-protein-coupled receptor sequences from the tissue of choice since these are not necessarily identical to already known G-protein-coupled receptors, but this is well understood by those of ordinary skill in the art. *See, e.g., Buck & Axel (1991), Cell 65:175-187.*

#### 5.1.1.1.2 Hybridization Assay Probes

Hybridization assay probes can be designed based on sequence information obtained from cloned mGluRs and amino acid sequences encoding such receptors such as the novel mGluR that is the subject of this invention. Hybridization assay probes can be designed to detect the presence of a particular nucleic acid target sequence perfectly complementary to the probe and target sequences of lesser complementarity by varying the hybridization conditions and probe design.

DNA probes targeted to metabotropic glutamate receptors can be designed and used under different hybridization conditions to control the degree of specificity needed for hybridization to a target sequence. Factors affecting probe design, such as length, G and C content, possible self-complementarity, and wash conditions, are known in the art. *See, e.g., Sambrook et al. (1989), Molecular Cloning (Cold Spring Harbor Laboratory Press).* Sambrook et al. also discusses the design and use of degenerate probes based on sequence polypeptide information.

As a general guideline, high stringency conditions (hybridization at 50-65°C, 5X SSPC, 50% formamide, wash at 50-65°C, 0.5X SSPC) can be used to obtain hybridization between nucleic acid sequences having regions which are greater than about 90% complementary. Low stringency conditions (hybridization at 35-37°C, 5X SSPC, 40-45% formamide, wash at 42°C 2X SSPC) can be used so that sequences having regions which are greater than 35-45% complementary will hybridize to the probe.

Many tissues or cells can be used as a source for genomic DNA, including for example placenta or peripheral blood leukocytes. However, with respect to RNA, the most preferred source is a tissue or cell type which expresses elevated levels of the desired metabotropic glutamate receptor family member.

### 5                   5.1.2   Novel Metabotropic Glutamate Receptor Nucleic Acid Derivatives

The isolated nucleic acid sequences of the invention also provide for the creation of modified nucleic acids with practical utility. The nucleic acid sequence can be mutated *in vitro* or *in vivo* to, for example, (1) create variations in coding regions thereby generating metabotropic glutamate receptor variants or derivatives; (2) form new restriction endonuclease sites or destroy  
10   preexisting ones, to facilitate further *in vitro* modification or (3) form new splice sites to create mGluR splice variants. Standard recombinant techniques for mutagenesis such as *in vitro* site-directed mutagenesis (Hutchinson et al. (1978), *J. Biol. Chem.* 253:6551; Sambrook et al., Chapter 15), use of TAB® linkers (Pharmacia), and PCR-directed mutagenesis can be used to create such mutations.

15           Additionally, nucleic acid sequences of the current invention can be engineered and recombined with nucleic acids encoding other receptors to form nucleic acids encoding chimeric receptors. Such nucleic acids encoding chimeric receptors are described in, for example, pending U.S. Patent No. 5,981,195.

Preferred receptor fragments include those having functional receptor activity, a binding  
20   site, epitope for antibody recognition (typically at least six amino acids), and/or a site which binds a metabotropic glutamate receptor agonist or antagonist. Other preferred receptor fragments include those having only an extracellular portion, a transmembrane portion, an intracellular portion, and/or a multiple transmembrane portion (e.g., seven transmembrane portion). Such receptor fragments have various uses such as being used to obtain antibodies to  
25   a particular region and being used to form chimeric receptors with fragments of other receptors to create a new receptor having unique properties. Such purified receptor fragments and chimeric receptors are described in, for example, pending U.S. Patent No. 5,981,195. Thus, as described in the Summary above, the invention features derivatives of full-length metabotropic glutamate receptors and fragments thereof having the same, or substantially the same, activity as the full-  
30   length parent metabotropic glutamate receptor or fragment. Such derivatives include amino acid addition(s), substitution(s), and deletion(s) to the receptor which do not prevent the derivative receptor from carrying out one or more of the activities of the parent receptor. Functional

equivalents of a metabotropic glutamate receptor protein include but are not limited to, such derivatives.

### 5.1.3 Transfected Cell Lines

5 Nucleic acid expressing a functional metabotropic glutamate receptor can be used to create transfected cell lines which functionally express a specific metabotropic glutamate receptor. Such cell lines have a variety of uses such as being used for high-throughput screening for molecules able to modulate metabotropic glutamate receptor activity; and being used to assay binding to a metabotropic glutamate receptor, and for production of metabotropic glutamate receptor peptides.

10 A variety of cell lines are capable of coupling exogenously expressed receptors to endogenous functional responses. A number of these cell lines (e.g., NIH-3T3, HeLa, NG115, CHO, HEK 293 and COS7) can be tested to confirm that they lack an endogenous metabotropic glutamate receptor. Those lines lacking a response to external glutamate can be used to establish stably transfected cell lines expressing the cloned metabotropic glutamate receptor.

15 Production of these stable transfectants is accomplished by transfection of an appropriate cell line with an eukaryotic expression vector, such as pCEP4, in which the coding sequence for the metabotropic glutamate receptor cDNA has been cloned into the multiple cloning site. These expression vectors contain a promoter region, such as the human cytomegalovirus promoter (CMV), that drive high-level transcription of cDNAs in a variety of mammalian cells. In addition, these vectors contain genes for the selection of cells that stably express the cDNA of interest. The selectable marker in the pCEP4 vector encodes an enzyme that confers resistance to hygromycin, a metabolic inhibitor that is added to the culture to kill the nontransfected cells. A variety of expression vectors and selection schemes are usually assessed to determine the optimal conditions for the production of metabotropic glutamate receptor-expressing cell lines for use in high-throughput screening assays.

25 The most effective method for transfection of eukaryotic cell lines with plasmid DNA varies with the given cell type. The metabotropic glutamate receptor expression construct will be introduced into cultured cells by the appropriate technique, either calcium phosphate precipitation, DEAE-dextran transfection, lipofection or electroporation.

30 Cells that have stably incorporated the transfected DNA will be identified by their resistance to selection media, as described above, and clonal cell lines will be produced by expansion of resistant colonies. The expression of the metabotropic glutamate receptor cDNA

by these cell lines will be assessed by solution hybridization and Northern blot analysis. Functional expression of the receptor protein will be determined by measuring the inhibition of adenylate cyclase activity and the subsequent reduction in cAMP accumulation in response to externally applied metabotropic glutamate receptor agonists; or by measuring the mobilization of intracellular calcium in response to externally applied metabotropic glutamate receptor agonists.

In a preferred embodiment of the current invention, the nucleic acid used to create a stably transfected eukaryotic cell line codes for SEQ ID NO: 2, more preferably, the nucleic acid is that represented by SEQ ID NO: 1, and/or various modified derivatives thereof including: (1) derivatives encoding receptor mutants, (2) derivatives encoding chimeric receptors, or (3) derivatives encoding receptor fragments.

#### **5.1.4 Novel Metabotropic Glutamate Receptor Protein, Derivatives and Fragments**

##### **5.1.4.1 Metabotropic Glutamate Receptor Proteins**

Recombinant metabotropic glutamate receptor proteins can be expressed in a variety of tissue and cell types including human tissue and cell types. These recombinant metabotropic glutamate receptor proteins can be utilized for a variety of purposes by those skilled in the art. The recombinant receptor proteins can be used as a source of antigen for the production of antibodies directed against metabotropic glutamate receptors, including polyclonal and monoclonal antibodies. In addition, recombinant metabotropic glutamate receptor proteins can be utilized for drug discovery purposes utilizing methods known to those skilled in the art. The recombinant receptor proteins can be utilized to screen (including high through-put screening) for molecules that bind to metabotropic glutamate receptors; as well as to screen for molecules that can modulate metabotropic glutamate receptor activity by acting as agonists, antagonists, or allosteric modulators. Finally, recombinant metabotropic glutamate receptor proteins can be used for structural studies of small molecule drug interactions with metabotropic glutamate receptors; antibody interactions with metabotropic glutamate receptors; or the interactions of other peptides and proteins with metabotropic glutamate receptors. These uses of metabotropic glutamate receptor proteins are not meant to be limiting.

In a preferred embodiment of the current invention the recombinant metabotropic receptor protein is an human metabotropic glutamate receptor protein, and more specifically it is a recombinant metabotropic glutamate receptor protein having the amino acid sequence

represented in SEQ ID NO: 2 or a biologically active portion of that sequence, or a functional equivalent.

#### 5.1.4.2 Metabotropic Glutamate Receptor Derivatives

Derivatives of a particular receptor are functional equivalents to that receptor, having  
5 similar amino acid sequence and retaining, to some extent, one or more activities of the related receptor. By "functional equivalent" is meant a protein that has an activity that can be substituted for one or more activities of a particular receptor or receptor fragment. Preferred functional equivalents retain all of the activities of a particular receptor or receptor fragment, however, the functional equivalent may have an activity that, when measured quantitatively, is  
10 stronger or weaker than the related receptor, as measured in standard receptor assays, for example, such as those disclosed herein. Preferred functional equivalents have activities that are within 1% to 10,000% of the activity of the related receptor, more preferably between 10% to 1000%, and more preferably within 50% to 500%. Functional equivalents may include, for example, derivatives which contain modifications or amino acid alterations in, for example, the  
15 region of a receptor which contains ligand binding activity. Such amino acid alterations may either increase or decrease the binding activity of the receptor with a particular binding agent. Functional equivalents may also include, for example, derivatives which contain modifications or amino acid alterations in the intracellular domain portion of the receptor which may, for example, increase or decrease the activity of the receptor by, for example, increasing or  
20 decreasing the cellular response to receptor activation. Derivatives have at least 15% sequence similarity, preferably 70%, more preferably 90%, even more preferably 95% sequence similarity to the related receptor. "Sequence similarity" refers to "homology" observed between amino acid sequences in two different polypeptides, irrespective of polypeptide origin.

The ability of the derivative to retain some activity can be measured using techniques  
25 described herein. Derivatives include modification occurring during or after translation, for example, by phosphorylation, glycosylation, crosslinking, acylation, proteolytic cleavage, linkage to an antibody molecule, membrane molecule or other ligand. *See* Ferguson et al. (1988), *Annu. Rev. Biochem.* 57:285-320.

Specific types of derivatives also include amino acid alterations such as deletions,  
30 substitutions, additions, and amino acid modifications. A "deletion" refers to the absence of one or more amino acid residue(s) in the related polypeptide. An "addition" refers to the presence of one or more amino acid residue(s) in the related polypeptide. Additions and deletions to a

polypeptide may be at the amino terminus, the carboxy terminus, and/or internal. Amino acid "modification" refers to the alteration of a naturally occurring amino acid to produce a non-naturally occurring amino acid. A "substitution" refers to the replacement of one or more amino acid residue(s) by another amino acid residue(s) in the polypeptide. Derivatives can contain  
5 different combinations of alterations including more than one alteration and different types of alterations.

While the effect of an amino acid change varies depending upon factors such as phosphorylation, glycosylation, intra-chain linkages, tertiary structure, and the role of the amino acid in the active site or a possible allosteric site, it is generally preferred that the substituted  
10 amino acid is from the same group as the amino acid being replaced. To some extent the following groups contain amino acids which are interchangeable: the basic amino acids lysine, arginine, and histidine; the acidic amino acids aspartic and glutamic acids; the neutral polar amino acids serine, threonine, cysteine, glutamine, asparagine and, to a lesser extent, methionine; the nonpolar aliphatic amino acids glycine, alanine, valine, isoleucine, and leucine (however,  
15 because of size, glycine and alanine are more closely related and valine, isoleucine and leucine are more closely related); and the aromatic amino acids phenylalanine, tryptophan, and tyrosine. In addition, although classified in different categories, alanine, glycine, and serine seem to be interchangeable to some extent, and cysteine additionally fits into this group, or may be classified with the polar neutral amino acids.

20 While proline is a nonpolar neutral amino acid, its replacement represents difficulties because of its effects on conformation. Thus, substitutions by or for proline are not preferred, except when the same or similar conformational results can be obtained. The conformation conferring properties of proline residues may be obtained if one or more of these is substituted by hydroxyproline (Hyp).

25 Examples of modified amino acids include the following: altered neutral nonpolar amino acids such as amino acids of the formula  $H_2N(CH_2)_nCOOH$  where  $n$  is 2-6, sarcosine (Sar), t-butylalanine (t-BuAla), t-butylglycine (t-BuGly), N-methyl isoleucine (N-MeIle), and norleucine (Nleu); altered neutral aromatic amino acids such as phenylglycine; altered polar, but neutral amino acids such as citrulline (Cit) and methionine sulfoxide (MSO); altered neutral and  
30 nonpolar amino acids such as cyclohexyl alanine (Cha); altered acidic amino acids such as cysteic acid (Cya); and altered basic amino acids such as ornithine (Orn).



Preferred derivatives have one or more amino acid alteration(s) which do not significantly affect the receptor activity of the related receptor protein. In regions of the metabotropic glutamate receptor protein not necessary for receptor activity amino acids may be deleted, added or substituted with less risk of affecting activity. In regions required for receptor activity, amino acid alterations are less preferred as there is a greater risk of affecting receptor activity. Such alterations should be conservative alterations. For example, one or more amino acid residues within the sequence can be substituted by another amino acid of a similar polarity which acts as a functional equivalent.

Conserved regions tend to be more important for protein activity than non-conserved regions. Standard procedures can be used to determine the conserved and non-conserved regions important for receptor activity using *in vitro* mutagenesis techniques or deletion analyses and measuring receptor activity as described by the present disclosure.

Derivatives can be produced using standard chemical techniques and recombinant nucleic acid techniques. Modifications to a specific polypeptide may be deliberate, as through site-directed mutagenesis and amino acid substitution during solid-phase synthesis, or may be accidental such as through mutations in hosts which produce the polypeptide. Polypeptides including derivatives can be obtained using standard techniques such as those described above, as well as techniques described by Sambrook et al. (1989), *Molecular Cloning* (Cold Spring Harbor Laboratory Press). For example, Chapter 15 of Sambrook describes procedures for site-directed mutagenesis of cloned DNA.

In a preferred embodiment of the current invention, the polypeptide subject to modification is that of a human metabotropic glutamate receptor, and more specifically, is a polypeptide having the amino acid sequence represented in SEQ ID NO: 2.

#### 5.1.4.3 Metabotropic Glutamate Receptor Fragments

Receptor fragments are portions of metabotropic glutamate receptors. Receptor fragments preferably bind to one or more binding agents which bind to a full-length receptor. Binding agents include ligands, such as glutamate, quisqualate, agonists, antagonists, allosteric modulators, and antibodies which bind to the receptor. Fragments have different uses such as to select other molecules able to bind to a receptor.

Fragments can be generated using standard techniques such as expression of cloned partial sequences of receptor DNA and proteolytic cleavage of a receptor protein. Proteins are specifically cleaved by proteolytic enzymes, such as trypsin, chymotrypsin or pepsin. Each of

these enzymes is specific for the type of peptide bond it attacks. Trypsin catalyzes the hydrolysis of peptide bonds whose carbonyl group is from a basic amino acid, usually arginine or lysine. Pepsin and chymotrypsin catalyze the hydrolysis of peptide bonds from aromatic amino acids, particularly tryptophan, tyrosine and phenylalanine.

5            Alternate sets of cleaved protein fragments are generated by preventing cleavage at a site which is susceptible to a proteolytic enzyme. For example, reaction of the  $\epsilon$ -amino group of lysine with ethyltrifluorothioacetate in mildly basic solution yields a blocked amino acid residue whose adjacent peptide bond is no longer susceptible to hydrolysis by trypsin. Goldberger et al. (1962), *Biochemistry* 1:401. Treatment of such a polypeptide with trypsin thus cleaves only at  
10           the arginyl residues.

Polypeptides also can be modified to create peptide linkages that are susceptible to proteolytic enzyme-catalyzed hydrolysis. For example, alkylation of cysteine residues with *b*-haloethylamines yields peptide linkages that are hydrolyzed by trypsin. Lindley (1956), *Nature*, 178:647.

15           In addition, chemical reagents that cleave polypeptide chains at specific residues can be used. Witcop (1961), *Adv. Protein Chem.* 16:221. For example, cyanogen bromide cleaves polypeptides at methionine residues. Gross & Witkop (1961), *J. Am. Chem. Soc.* 83:1510.

             Thus, by treating a metabotropic glutamate receptor, or fragments thereof, with various combinations of modifiers, proteolytic enzymes and/or chemical reagents, numerous discrete  
20           overlapping peptides of varying sizes are generated. These peptide fragments can be isolated and purified from such digests by chromatographic methods. Alternatively, fragments can be synthesized using an appropriate solid-state synthetic procedure.

             Fragments may be selected to have desirable biological activities. For example, a fragment may include just a ligand binding site. Such fragments are readily identified by those  
25           of ordinary skill in the art using routine methods to detect specific binding to the fragment. For example, in the case of a metabotropic glutamate receptor, nucleic acid encoding a receptor fragment can be expressed to produce the polypeptide fragment which is then contacted with a receptor ligand under appropriate association conditions to determine whether the ligand binds to the fragment. Such fragments are useful in screening assays for agonists and antagonists of  
30           glutamate.

Other useful fragments include those having only the external portion, membrane-spanning portion, or intracellular portion of the receptor. These portions are readily identified

by comparison of the amino acid sequence of the receptor with those of known receptors, or by other standard methodology. These fragments are useful for forming chimeric receptors with fragments of other receptors to create a receptor with an intracellular portion which performs a desired function within that cell, and an extracellular portion which causes that cell to respond to the presence of glutamate, or those agonists or antagonists described herein. For example, chimeric receptors can be constructed such that the intracellular domain is coupled to a desired enzymatic process which can be readily detected by colorimetric, radiometric, luminometric, spectrophotometric or fluorimetric assays and is activated by interaction of the extracellular portion with its native ligand (e.g., glutamate) or agonist and/or antagonists of the invention. Cells expressing such chimeric receptors can be used to facilitate screening of metabotropic glutamate receptor agonists and antagonists.

In a preferred embodiment of the current invention, the polypeptide fragments are fragments of a human metabotropic glutamate receptor, and more specifically, are fragments of the polypeptide having the amino acid sequence represented in SEQ ID NO: 2.

#### 5.1.5 Compounds Targeted to the Novel Metabotropic Glutamate Receptor

The mGluR agonist and antagonist compounds described in the scientific literature are related to the endogenous agonist, glutamate. (For reviews, see Cockcroft et al. (1993), *Neurochem. Int.* 23:583-594; Schoepp & Conn (1993), *Trends Pharmacol. Sci.* 14:13-20; Hollmann & Heinemann (1994), *Annu. Rev. Neurosci.* 17:31-108; Watkins & Collinridge (1994), *Trends Pharmacol. Sci.* 15:333; Knopf et al. (1995), *J. Med. Chem.* 38:1417.) Such agonist and antagonist compounds have an acidic moiety, usually a carboxylic acid, but sometimes a phosphonic acid. Presumably then, such compounds bind mGluRs at the same site as the amino acid, glutamate. This has been confirmed for methylcarboxyphenylglycine, which was shown to be a competitive antagonist of glutamate. Eaton et al. (1993), *Eur. J. Pharm. - Mol. Pharm. Sect.* 244:195-197. Since these compounds are for the most part amino acids or amino acid derivatives, they have limited bioavailabilities, which hampers *in vivo* studies assessing mGluR physiology, pharmacology and therapeutic potential. In addition, the currently available mGluR agonists and antagonists are of limited use, both as research tools and potential therapeutic agents, as a result of their lack of potency and selectivity. The identification of agonists and antagonists with a high degree of potency and selectivity for individual mGluR subtypes is therefore the most important requirement to increase the understanding of various mGluRs' roles in physiological and pathophysiological processes in the mammalian CNS.

The isolation of the nucleic acid encoding the novel mGluR of the present invention allows for the receptor's expression in transfected cell lines, and these cells can be utilized to screen for novel compounds capable of binding to and modulating the activity of the novel mGluR. These compounds could bind at the same site as glutamate, or alternatively at novel binding sites on the mGluR protein. Such screening can identify compounds with improved potency and selectivity for the novel mGluR. These compounds may also have other beneficial characteristics such as improved bioavailability. Such compounds would have utility as improved research tools for deducing the novel mGluR's physiological and pathophysiological roles, and as potential therapeutic agents.

Compounds targeted to the novel metabotropic glutamate receptor can have several uses including therapeutic uses and diagnostic uses. Those compounds binding to a metabotropic glutamate receptor and those compounds efficacious in modulating metabotropic receptor glutamate activity can be identified using the procedures described herein. Those compounds which can selectively bind to the metabotropic glutamate receptor can be used therapeutically, or alternatively as diagnostics to determine the presence of the metabotropic glutamate receptor versus other glutamate receptors.

#### 5.1.6 Modulation of Metabotropic Glutamate Receptor Activity

Modulation of metabotropic glutamate receptor activity can be used to produce different effects such as anticonvulsant effects, neuroprotectant effects, analgesic effects, cognition-enhancement effects, and muscle-relaxation effects. Each of these effects has therapeutic applications. Compounds used therapeutically should have minimal side effects at therapeutically effective doses.

Modulating metabotropic glutamate receptor activity causes an increase or decrease in a cellular response which occurs upon metabotropic glutamate receptor activation. Cellular responses to metabotropic glutamate receptor activation vary depending upon the type of metabotropic glutamate receptor activated. Generally, metabotropic glutamate receptor activation causes one or more of the following activities: (1) activation of phospholipase C, (2) increases in phosphoinositide (PI) hydrolysis, (3) intracellular calcium release, (4) activation of phospholipase D, (5) activation or inhibition of adenylyl cyclase, (6) increases or decreases in the formation of cyclic adenosine monophosphate (cAMP), (7) activation of guanylyl cyclase, (8) increases in the formation of cyclic guanosine monophosphate (cGMP), (9) activation of phospholipase A<sub>2</sub>, (10) increases in arachidonic acid release, and (11) increases or decreases in

the activity of ion channels, for example voltage- and ligand-gated ion channels. Inhibition of metabotropic glutamate receptor activation prevents one or more of these activities from occurring.

Activation of a particular metabotropic glutamate receptor refers to the production of one or more activities associated with the type of receptor activated, for example: (1) activation of phospholipase C, (2) increases in phosphoinositide (PI) hydrolysis, (3) intracellular calcium release, (4) activation of adenylyl cyclase, (5) increases in the formation of cyclic adenosine monophosphate (cAMP), (6) activation of phospholipase A<sub>2</sub>, (7) increases in arachidonic acid release, (8) increases or decreases in ion channel activity.

The ability of a compound to modulate metabotropic glutamate activity can be monitored using electrophysiological and biochemical assays measuring one or more metabotropic glutamate activities. Examples of such assays include the electrophysiological assessment of metabotropic glutamate receptor function in *Xenopus* oocytes expressing cloned metabotropic glutamate receptors, the electrophysiological assessment of metabotropic glutamate receptor function in transfected cell lines (e.g., CHO cells, HEK 293 cells, etc.) expressing cloned metabotropic glutamate receptors, the biochemical assessment of PI hydrolysis and cAMP accumulation in transfected cell lines expressing cloned metabotropic glutamate receptors, the biochemical assessment of PI hydrolysis and cAMP accumulation in rat brain (e.g., hippocampal, cortical, striatal, etc.) slices, fluorimetric measurements of cytosolic Ca<sup>2+</sup> in cultured rat cerebellar granule cells, and fluorimetric measurements of cytosolic Ca<sup>2+</sup> in transfected cell lines expressing cloned metabotropic glutamate receptors.

Prior to therapeutic use in a human, the compounds are preferably tested *in vivo* using animal models. Animal studies to evaluate a compound's effectiveness to treat different diseases or disorders, or exert an effect such as an analgesic effect, a cognition-enhancement effect, or a muscle-relaxation effect, can be carried out using standard techniques.

#### 5.1.7 *In Vitro* Diagnostics

The different molecules of the present invention can be used to facilitate diagnosis of metabotropic glutamate receptor-related diseases. Diagnosis can be carried out *in vitro* or *in vivo*. For example, the molecules of the present invention can be used to assay for defects in metabotropic glutamate receptors.

Nucleic acid probes can be used to identify defects in metabotropic glutamate receptors occurring at the genetic level. For example, hybridization probes complementary to nucleic acid

encoding a receptor can be used to clone the receptor. The cloned receptor can be inserted into a cell, such as an oocyte, and its responsiveness to an mGluR ligand determined. Another example of using hybridization assay probes to detect defects involves using the probes to detect mRNA levels or the presence of nucleic acid sequences associated with a particular disease. A decreased mRNA level would be consistent with a decreased amount of expressed receptor.

All publications, patents, and patent applications cited in this application are hereby incorporated by reference in their entirety.

## 6. EXAMPLES

Examples are provided below to illustrate different aspects and embodiments of the present invention. These examples are not intended in any way to limit the disclosed invention. Rather, they illustrate methodologies by which the novel human mGluR5 splice variant of the present invention may be isolated, expressed in eukaryotic systems, and assessed for functional activity. They also illustrate methodologies by which compounds may be screened to identify those which bind to or modulate the activity of the novel human mGluR5 splice variant.

### **Example 1 - Cloning of a Novel Human mGluR5 Splice Variant**

Numbering of nucleotide positions for all the following constructs is such that nucleotide number 1 corresponds to the A of the ATG start codon of the nucleotide sequence encoding the designated protein.

The 5' portion of human mGluR5 was amplified from human hippocampus Marathon-Ready™ cDNA (CLONTECH Laboratories, Inc.) using PCR primers based on the human mGluR5a cDNA sequence (Genbank Accession No. D28538). The primers used were the Marathon Adaptor Primer (AP1; CLONTECH) and the gene-specific primer, hR5UP (antisense 25mer, complementary to nucleotides 2301-2325 of human mGluR5). Amplification products were subjected to agarose gel electrophoresis and those corresponding to approximately 2500 bp in size were gel isolated and subcloned into the Bluescript SK(-) plasmid (Stratagene) following digestion of both plasmid and PCR product with NotI and EcoRV restriction endonucleases. DNA sequence analysis of the subclones via double-stranded DNA sequencing with Sequenase Version 2.0 (US Biochemical) confirmed human mGluR5 sequence.

The 3' portion of human mGluR5d was also amplified from human hippocampus Marathon-Ready™ cDNA (CLONTECH Laboratories, Inc.) using the Marathon Adaptor Primer (AP1; CLONTECH) and the gene-specific primers, hR5DN (sense 25mer, corresponding to

nucleotides 2061-2085 of human mGluR5) and the nested gene-specific primer, R5DN2 (sense, 27mer, corresponding to nucleotides 2149-2175). Agarose gel electrophoresis revealed multiple products diverse in size. This collection of products was gel isolated and subcloned into the Bluescript SK(-) plasmid (Stratagene) following digestion of both plasmid and PCR products with NotI and EcoRV restriction endonucleases. DNA sequence analysis of the subclones via double-stranded DNA sequencing with Sequenase Version 2.0 (US Biochemical) revealed the presence of a novel 3' splice variant of human mGluR5.

To construct a full-length human mGluR5d ("hmGluR5d") construct, the 5' mGluR5 construct was digested with the restriction endonuclease SacII, blunted with T4 DNA Polymerase, then digested the NheI. The 3' hmGluR5d construct was digested with PstI, blunted with T4 DNA Polymerase, then digested with NheI. The 5' insert of approximately 2kb was gel isolated and ligated to the Bluescript SK(-) vector containing the 3' human mGluR5d fragment. The sequence of the resultant full-length human mGluR5d was verified by ABI automated sequence analysis. This construct is referred to as phmGluR5d(SK-).

The full-length human mGluR5d was then subcloned into the mammalian expression vector pcDNA3.1/Hygro(+) vector (Invitrogen) using the restriction endonucleases HindIII and NotI. This construct is referred to as phmGluR5d(Hyg+).

The nucleotide sequence of the human mGluR5d cDNA is depicted in SEQ ID NO: 1. The open reading frame is 2826 bp.

The 2826 bp open reading frame of the human mGluR5d cDNA encodes a 942 amino acid protein (SEQ ID NO: 2). The amino acid sequence of the novel human mGluR5d splice variant is identical to the human mGluR5b amino acid sequence up to residue 895, with a deletion of 270 amino acids within the C-terminal tail (Figures 1A & 1B).

#### **Example 2 - Construction of a Chimeric Receptor Between the Human Calcium**

##### **Receptor and the Human mGluR5d Splice Variant**

This chimera contains the extracellular domain of the human calcium receptor ("CaR") (Garrett et al. (1995), *J. Biol. Chem.* 270:12919) and transmembrane domain and intracellular cytoplasmic tail of the human mGluR5d splice variant. The chimeric junction between the CaR and hmGluR5d was created using a recombinant PCR strategy.

The first reaction used two primers, CA1156 (sense 19-mer, corresponding to nucleotides 1156-1174 of human CaR), and the hybrid primer CA/5 (antisense 42-mer, containing 21 nucleotides complementary to nucleotides 1774-1794 of human CaR and 21 nucleotides

complementary to nucleotides 1696-1716 of the human mGluR5d). These primers were used to amplify a 659 bp PCR fragment of human CaR from the plasmid phCaR in Bluescript SK(-).

5 In a separate PCR reaction using phmGluR5d(SK-) as template, an 800 bp fragment of the human mGluR5d was amplified using a hybrid primer 5/CA (sense 42-mer, exactly complementary to primer CA/5) and oligo 5-2475m, (antisense 17-mer, complementary to nucleotides 2459-2475 of the human mGluR5d cDNA). The two PCR products generated from the above two reactions were annealed together in equimolar ratios in the presence of the external primers CA1156 and 5-2475m, and the Pfu DNA polymerase (Stratagene).

10 The resulting chimeric PCR product was digested with SexA1 (Boehringer Mannheim) and NheI (New England Biolabs) and subcloned into phCaR digested with the same two restriction enzymes. In the final cloning step, the 3' end of human mGluR5d was subcloned into this construct using the restriction enzymes NheI and NotI (both New England Biolabs). The sequence of the resultant chimeric construct, phCaR/hmGluR5d, was verified by ABI automated DNA sequence analysis. The 2925 bp open reading frame (SEQ ID NO: 3) of the hCaR/hmGluR5d chimera encodes a 975 amino acid protein (SEQ ID NO: 4).

15 The chimeric receptor was then subcloned into the mammalian expression vector pcDNA3.1/Hygro(+) vector (Invitrogen) using the restriction endonucleases HindIII and NotI. This construct is referred to as phCaR/hmGluR5d(Hyg+).

20 A chimeric receptor having an extracellular domain and seven transmembrane domain of mGluR5d and an intracellular cytoplasmic tail domain of a G-protein-coupled calcium receptor could also be constructed using well-known techniques. *See, e.g.*, U.S. Patent No. 5,981,195. The amino acid sequence of such a chimeric receptor is given in SEQ ID NO: 6, and a representative nucleotide sequence coding for such a chimeric receptor is given in SEQ ID NO: 5.

### 25 **Example 3 - Functional Activation of the Novel Metabotropic Glutamate Receptor 5 Splice Variant Expressed in *Xenopus* Oocytes**

30 This example describes the activation of the novel hmGluR5d splice variant using a *Xenopus* oocyte expression assay. PhmGluR5d(Hyg+) DNA was linearized by restriction enzyme digestion, and capped sense-strand cRNA was synthesized by T7 RNA polymerase transcription (Ambion Message Machine Kit). *In vitro*-transcribed RNA was concentrated by ethanol precipitation and the size and integrity of the RNA was assessed on a denaturing agarose gel.



Oocytes suitable for injection were obtained from adult female *Xenopus laevis* toads using procedures described in Marcus-Sekura & Hitchcock (1987), *Methods in Enzymology* 152. *In vitro*-transcribed RNA (~10 ng) encoding the human mGluR5d receptor was injected into *Xenopus* Oocytes. Following injection, oocytes were incubated at 16°C in MBS containing 1 mM CaCl<sub>2</sub> for

2 to 7 days prior to electrophysiological recording. Following the incubation, the oocytes were voltage-clamped using standard electrophysiological techniques. Hille (1992), *Ionic Channels of Excitable Membranes*, pp. 30-33 (Sinauer Associates, Inc., Sunderland, MA). Activation of the hmGluR5d receptor was detected by increases in the calcium-activated chloride current.

Test substances were applied by superfusion at a flow rate of about 5 ml/min. Receptor activation was determined by measuring the increase in calcium-activated chloride current ( $I_{Cl}$ ). Increases in  $I_{Cl}$  were quantified by measuring the peak inward current stimulated by activating agent, relative to the holding current at 60 mV. Application of the mGluR activators 100  $\mu$ M L-glutamate or other agonists, resulted in reversible, oscillatory increases in the calcium-activated chloride current as shown in Figure 3. These data demonstrate the functional response of the novel human mGluR5d receptor.

Interestingly, in contrast to the other mGluR5 splice variants, mGluR5a and mGluR5b, human mGluR5d displays little desensitization in response to agonists. Gereau & Heineman (1998), *Neuron* 20:143, investigated the molecular mechanisms of rat mGluR5 desensitization and found that both mGluR5a and mGluR5b undergo a relatively rapid PKC-mediated phosphorylation that leads to agonist-induced desensitization of mGluR5-mediated chloride currents in *Xenopus* oocytes. Furthermore, mutations in five PKC consensus sites abolished this desensitization. Two of these sites in the cytoplasmic tail (S881 and S890 in rat mGluR5a, corresponding to S914 and S923 in hmGluR5b, as shown in Figure 1B) are not present in the novel human mGluR5d splice variant. Repeated application of 10-100  $\mu$ M L-glutamate or (S)-3,5-dihydroxyphenylglycine (DHPG) to *Xenopus* oocytes expressing hmGluR5d evoked calcium-activated chloride currents, which were only minimally desensitized. The reduced desensitization properties of hmGluR5d splice variant may produce a variety of physiological responses in the CNS during development, normal synaptic function and pathological conditions.

#### Example 4 - Transient and Stable Expression of the Novel Human mGluR5d Splice Variant in Mammalian Cells

This example provides a method for the production of stably transfected mammalian cell lines expressing the novel human mGluR, but is not meant to be limiting. Human embryonic kidney cells (293, ATCC, CRL 1573) are grown in a routine manner. Cells are plated in 10cm cell-culture plates in Dulbecco's modified Eagle's medium (D-MEM) containing 10% fetal bovine serum (FBS) and 1X penicillin-streptomycin (Life Technologies) so that they are approximately 70% confluent after an overnight incubation. To prepare DNA for transfection, the plasmid phmGluR5d(Hyg+) is precipitated with ethanol, rinsed and resuspended in sterile water at a concentration of 1 µg/µl. Ten micrograms of the plasmid DNA is incubated with the liposome formulation LipofectAMINE™ (Life Technologies) for 20 minutes in 1.6 mls of serum-free Opti-MEM (Life Technologies). After the room temperature incubation, 6.4 mls of Opti-MEM is added to the transfection mix. This solution is added to the cells which have been rinsed twice with 8 ml washes of Opti-MEM. The cells and transfection mix are incubated at 37°C for 5 hours, at which time 8 mls of Opti-MEM/20% FBS is added to bring the FBS concentration to 10%. After an overnight incubation, the medium is changed back to D-MEM with 10% FBS and 2 mM glutamine. These transiently transfected cells can be tested for functional expression of the hmGluR5d receptor. (See Example 6, below.) For stable expression of human mGluR5d, transfections were performed as above, with a few modifications. To prevent tonic activation of hmGluR5d by glutamate that may be released by these cells into the extracellular medium, hmGluR5d was transfected into a clonal HEK293 cell line expressing a glutamate/aspartate transporter (GLAST) from a mammalian expression vector with Zeocin resistance. Desai et al. (1995), *Mol. Pharm.* 48:648. 48 hours post-transfection, these cells are detached with trypsin and replated in medium containing 200 µg/ml hygromycin (Boehringer Mannheim) and 200 µg/ml Zeocin (Invitrogen). Those cells which grow should contain phmGluR5d(Hyg+) which encodes the hygromycin resistance gene. Individual clonal cell lines are recovered and propagated using standard tissue culture techniques. Subcultures of both individual clonal cell lines and pools of many such cell lines can be prepared by dissociation into fresh tissue culture medium, and plating into fresh culture dishes with 1:10 splits of cells. Expression of the novel human mGluR5d splice variant of the present invention in clonal cell lines or pools can be assessed by Northern blot analysis of human mGluR5d mRNA or functionally as in the above experiments by assessing increases in intracellular calcium in response to mGluR5 agonists.

Expression can also be assessed by Western blot analysis using the commercially available antibody Anti-Rat mGluR5, polyclonal (Upstate Biotechnology).

**Example 5 - Transient and Stable Expression of the Chimeric Receptor,  
hCaR/hmGluR5d in Mammalian Cells**

5           This example provides a method for the production of stably transfected mammalian cell lines expressing the chimeric receptor hCaR/hmGluR5d, but is not meant to be limiting. Human embryonic kidney cells (293, ATCC, CRL 1573) are grown in a routine manner. Cells are plated in 10 cm cell-culture plates in Dulbecco's modified Eagle's medium (D-MEM) containing 10% fetal bovine serum (FBS) and 1X penicillin-streptomycin (Life Technologies) so that they are  
10           approximately 70% confluent after an overnight incubation. To prepare DNA for transfection, the plasmid phCaR/hmGluR5d(Hyg+) is precipitated with ethanol, rinsed and resuspended in sterile water at a concentration of 1 µg/µl. Ten micrograms of the plasmid DNA is incubated with the liposome formulation LipofectAMINE™ (Life Technologies) for 20 minutes in 1.6 mls of serum-free Opti-MEM (Life Technologies). After the room temperature incubation, 6.4 mls of  
15           Opti-MEM is added to the transfection mix. This solution is added to the cells which have been rinsed twice with 5 ml washes of Opti-MEM. The cells and transfection mix are incubated at 37°C for 5 hours, at which time 6.4 mls of Opti-MEM/20% FBS is added to bring the FBS concentration to 10%. After an overnight incubation, the medium is changed back to D-MEM with 10% FBS and 2 mM glutamine. After an additional 24 hour incubation, cells are detached  
20           with trypsin and replated in medium containing 200 µg/ml hygromycin (Boehringer Mannheim). Those cells which grow should contain phCaR/hmGluR5d(Hyg+), which encodes the hygromycin resistance gene. Individual clonal cell lines are recovered and propagated using standard tissue culture techniques. Subcultures of both individual clonal cell lines and pools of many such cell lines can be prepared by dissociation into fresh tissue culture medium, and plating into fresh  
25           culture dishes with 1:10 splits of cells. Expression of the novel chimeric receptor hCaR/hmGluR5d mRNA of the present invention in clonal cell lines can be assessed by Northern blot analysis to identify cell lines exhibiting high levels of mRNA expression. Expression can also be assessed by Western blot analysis using the commercially available antibody Anti-Rat mGluR5, polyclonal (Upstate Biotechnology).

30

**Example 6 - Functional Activation of the Novel Human mGluR5d Splice Variant  
Expressed in Mammalian Cells**

Group I metabotropic glutamate receptors mediate the stimulation of inositol phosphate (IP)/Ca<sup>2+</sup> signal transduction. Mammalian cell lines stably or transiently transfected with phmGluR5d(Hyg+) can be utilized to examine glutamate- (or other agonist-) induced increases in intracellular calcium. 48 hours post-transfection, cells are detached with trypsin and replated at a density of 4-5 x 10<sup>6</sup> cells/ml in the D-MEM medium in 96 well plates for functional testing. After an additional 24 hour incubation, cells are loaded with the calcium indicator dye Fluo3-AM, and increases in intracellular calcium in response to L-glutamate, (S)-3,5-dihydroxyphenylglycine (DHPG), trans-1-aminocyclopentane-1,3-dicarboxylic acid (*trans*-ACPD) and quisqualate are measured using an automated fluorescent imaging plate reader (FLIPR). An example of DHPG activation is shown in Figure 4.

**Example 7 - Functional Activation of the Chimeric Receptor, hCaR/hmGluR5d,  
Expressed in Mammalian Cells**

The chimeric receptor, hCaR/hmGluR5d, also mediates the stimulation of inositol phosphate (IP)/Ca<sup>2+</sup> signal transduction. Because this chimera contains the extracellular agonist binding domain of the CaR (Garrett et al. (1995), *J. Biol. Chem.* 270:12919) it is activated by calcium and other agonists of the CaR. Mammalian cell lines stably transfected with phCaR/hmGluR5d(Hyg+) can be utilized to examine calcium- (or other agonist-) induced increases in intracellular calcium. Stably transfected cells are detached with trypsin and replated at a density of 4-5 x 10<sup>6</sup> cells/ml in the D-MEM medium in 96 well plates for functional testing. After an additional 24 hour incubation, cells are loaded with the calcium indicator dye Fluo3-AM and increases in intracellular calcium in response to calcium are measured using an automated fluorescent imaging plate reader (FLIPR). An example of such activation is depicted in Figure 5.

**Example 8 - Recombinant Receptor Binding Assays**

The following is an example of a rapid screening assay to obtain compounds binding to the glutamate binding site of the novel human mGluR. The screening assay measures the binding of compounds to recombinant mGluRs expressed in stably transfected mammalian cells. O'Hara et al. (1993), *Neuron* 11:41. Cells stably or transiently transfected with the phmGluR5d(Hyg+) expression construct are grown to confluence, rinsed twice with PBS, and harvested by scraping in PBS. The harvested cells are pelleted by centrifugation at 1000 rpm for 5 minutes at 4°C, and

frozen at - 70°C. Cell membranes are prepared by homogenizing the pellet twice with 50 mM Tris-HCl (pH 7.4), 10 mM EDTA, 0.1 mM phenylmethylsulfonyl fluoride (PMSF), 0.1 mM D,L-benzylsuccinic acid, 10 µg/ml turkey egg white trypsin inhibitor; centrifugation at 30,000 x g for 10 minutes at 4°C; then treatment with DNase and collection by centrifugation. Membrane  
5 suspensions are washed twice and resuspended in 50 mM Tris-HCl (pH 7.4), 2.5 mM CaCl<sub>2</sub> (Tris/Ca) and the total protein concentration is adjusted to 450-675 µg/ml. For binding assays 25 µls of 200 nM [<sup>3</sup>H]glutamate (Dupont NEN) or other agonists, such as (S)-3,5-dihydroxyphenylglycine (DHPG), trans-1-aminocyclopentane-1,3-dicarboxylic acid (*trans*-ACPD) and quisqualate, are added to 225 µls of membrane suspension in the presence or absence  
10 of cold competitor (10 mM glutamate) and incubated on ice for 1 hour. Assays are stopped by rapid addition of four mls of ice-cold Tris/Ca buffer and immediate collection of the membranes on Whatman GF/C filters by vacuum filtration. Ten mls of Optiflour (Packard) is added to filters in scintillation vials and the bound radioactivity is quantified by scintillation counting.

The above example is not meant to be limiting. In a broader context, similar binding  
15 assays utilizing other radioligands binding to the glutamate binding site or other sites on the human mGluR5d splice variant can be developed by those skilled in the art. Such assays can be utilized to measure the binding of compounds to recombinantly expressed receptors, or receptor fragments. Compounds binding to the novel human mGluRd may then be examined for their ability to modulate one or more functional activities of this human mGluR5d variant.

#### 20 **Example 9 - Molecule Screening Using *Xenopus* Oocyte**

Oocytes injected with the hmGluR5d cRNA as described in Example 3 provide a system for assessing the actions of novel compounds on the novel human mGluR5d splice variant by measuring increases in the calcium-activated chloride current. Compounds can be assessed for functional activation of human mGluR5d in the absence of glutamate or other known mGluR  
25 agonists (agonist activity); accentuation of human mGluR5d activation by glutamate or other known mGluR agonist (positive allosteric modulation); or blockade of human mGluR5d activation by glutamate or other known mGluR5 agonists (antagonist activity).

#### **Example 10 - Molecule Screening Using Recombinant Human mGluR5d Splice Variant Expressed in Transfected Cell Lines**

30 Cell lines stably or transiently transfected with the novel human mGluR5d expression constructs as described in Example 4 can be utilized to assess the affinity of compounds on the novel human mGluR5d splice variant by utilizing binding assays as described in Example 8. *See*

Figure 2, in which the reported  $EC_{50}$  values for these agonists represent the mean and standard deviation from three independent experiments with multiple (6-18) determinations at each agonist concentration within an experiment. Stably transfected cells expressing hmGluR5d can be assayed in the same manner.

5           In addition, cell lines transfected with human mGluR5d splice variant expression constructs as described in Example 4 can be utilized to assess the actions of compounds on the novel human mGluR5d splice variant by measuring increases in intracellular calcium in response to the compound.

10           Compounds can be assessed for functional activation of human mGluR5d splice variant in the absence of glutamate or other known mGluR agonists (agonist activity); accentuation of human mGluR5d splice variant activation by glutamate or other known mGluR agonists (positive allosteric modulation); or blockade of human mGluR5d splice variant activation by glutamate or other known mGluR agonists (antagonist activity).

## CLAIMS:

1. An isolated and purified nucleic acid molecule, said nucleic acid molecule comprising nucleotides which code for the amino acid sequence of SEQ ID NO: 2.
2. An isolated and purified nucleic acid molecule comprising the nucleotide sequence  
5 of SEQ ID NO: 1.
3. A recombinant vector comprising the nucleic acid molecule of claim 2.
4. The recombinant vector of claim 3, wherein said recombinant vector is a plasmid.
5. The recombinant vector of claim 3, wherein said recombinant vector is a prokaryotic or eukaryotic expression vector.
- 10 6. The recombinant vector of claim 3, wherein the nucleic acid molecule is operably linked to a heterologous promoter.
7. A host cell comprising the nucleic acid molecule of claim 2.
8. The host cell of claim 7, wherein the host cell is a eukaryotic host cell.
9. The host cell of claim 7, wherein the host cell is a prokaryotic host cell.
- 15 10. An isolated and purified nucleic acid molecule, said nucleic acid molecule comprising nucleotides which code for residues 861 to 942 of the amino acid sequence of SEQ ID NO: 2.
11. A calcium receptor/metabotropic glutamate receptor chimeric receptor comprising an extracellular domain of a G-protein-coupled calcium receptor and a seven transmembrane  
20 domain and an intracellular cytoplasmic tail domain contained in the amino acid sequence of SEQ ID NO: 2.
12. The chimeric receptor of claim 11, wherein said chimeric receptor comprises the amino acid sequence of SEQ ID NO: 4.
13. An isolated and purified nucleic acid molecule, said nucleic acid molecule  
25 comprising nucleotides that encode the chimeric receptor of claim 11.
14. The nucleic acid molecule of claim 13, wherein said nucleic acid molecule comprises SEQ ID NO: 3.
15. A metabotropic glutamate receptor/calcium receptor chimeric receptor comprising an extracellular domain and a seven transmembrane domain contained in the amino acid sequence  
30 of SEQ ID NO: 2 and an intracellular cytoplasmic tail domain of a G-protein-coupled calcium receptor.

16. The chimeric receptor of claim 15, wherein said chimeric receptor comprises the amino acid sequence of SEQ ID NO: 6.

17. An isolated and purified nucleic acid molecule, said nucleic acid molecule comprising nucleotides that encode the chimeric receptor of claim 15.

5 18. The nucleic acid molecule of claim 17, wherein said nucleic acid molecule comprises SEQ ID NO: 5.

19. A method of screening for a compound that binds to or modulates the activity of a metabotropic glutamate receptor comprising SEQ ID NO: 2, or a biologically active portion thereof, comprising:

10 introducing said metabotropic glutamate receptor and a potential compound into an acceptable medium, and

monitoring the binding or modulation by physically detectable means, thereby identifying those compounds which interact with or modulate the activity of said metabotropic glutamate receptor.

15 20. The method of claim 19, wherein said metabotropic glutamate receptor is a chimeric receptor comprising an extracellular domain having an amino acid sequence contained in SEQ ID NO: 2, and

an intracellular domain of a receptor different than the receptor having the amino acid sequence SEQ ID NO: 2.

20 21. The method of claim 20, wherein the chimeric receptor comprises an intracellular domain of a G-protein-coupled calcium receptor.

22. The method of claim 21 wherein the chimeric receptor comprises SEQ ID NO: 6.

23. The method of claim 19, comprising a competition binding assay with a labeled known binding agent.

25 24. The method of claim 19, wherein the metabotropic glutamate receptor is expressed by a cell, further comprising monitoring the effect of said compound on said cell.

25. The method of claim 24 wherein the cell is a eukaryotic cell.

26. A method of screening for a compound that binds to or modulates the activity of a chimeric calcium receptor/metabotropic glutamate receptor comprising an extracellular domain of a G-protein-coupled calcium receptor and a seven transmembrane domain and an intracellular cytoplasmic tail domain contained in the amino acid sequence of SEQ ID NO: 2, or a biologically active portion thereof, comprising:

30



introducing said chimeric receptor and a potential compound into an acceptable medium, and

monitoring the binding or modulation by physically detectable means, thereby identifying those compounds which interact with or modulate the activity of said chimeric receptor.

5

27. The method of claim 26 wherein the chimeric receptor comprises SEQ ID NO: 4.

28. The method of claim 26, comprising a competition binding assay with a labeled known binding agent.

10

29. The method of claim 26, wherein the chimeric receptor is expressed by a cell, further comprising monitoring the effect of said compound on said cell.

30. The method of claim 29 wherein the cell is a eukaryotic cell.

803  
.....CFSVLSATVALGCMFVPKVYIILAKP

**TM VII**

ERNVRS AFTTSTVVRMHVGDGKSSSAASRSSS

LVNLWKRRGSSGETLRYKDRRLAQHKSEIECF

895 896  
TP / ..... / PSPFRDSVDSGSTTPNSPVSESA

**Site of Deletion**

LCIPSSPKYDTLIIRDY TQSSSSL 942

**FIGURE 1A**

KGSMGNGGRATMSSSNGKSVTWAQNEKSSRGQ  
                                  \*                                  \*

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SPDAGPKALYDVAEAEHFPAPARPRSPSPIS

TLSHRAGSASRTDDDVP SLHSEPVARSSSSSQG

SLMEQISSVVTRFTANISELNSMMLSTAAPSP

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**FIGURE 1B**

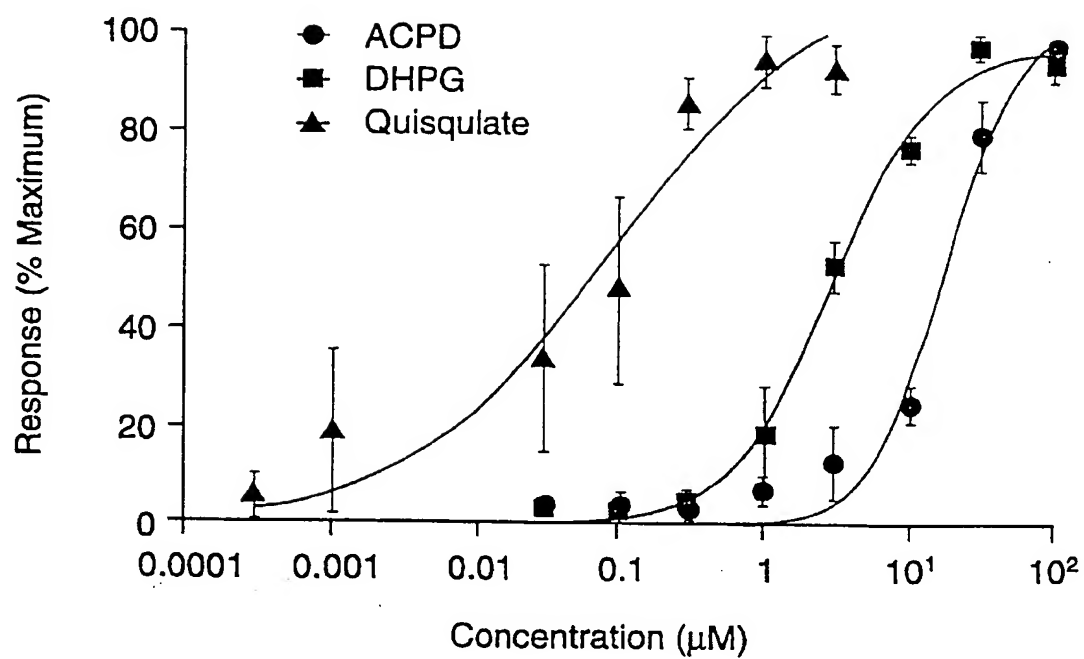


FIGURE 2

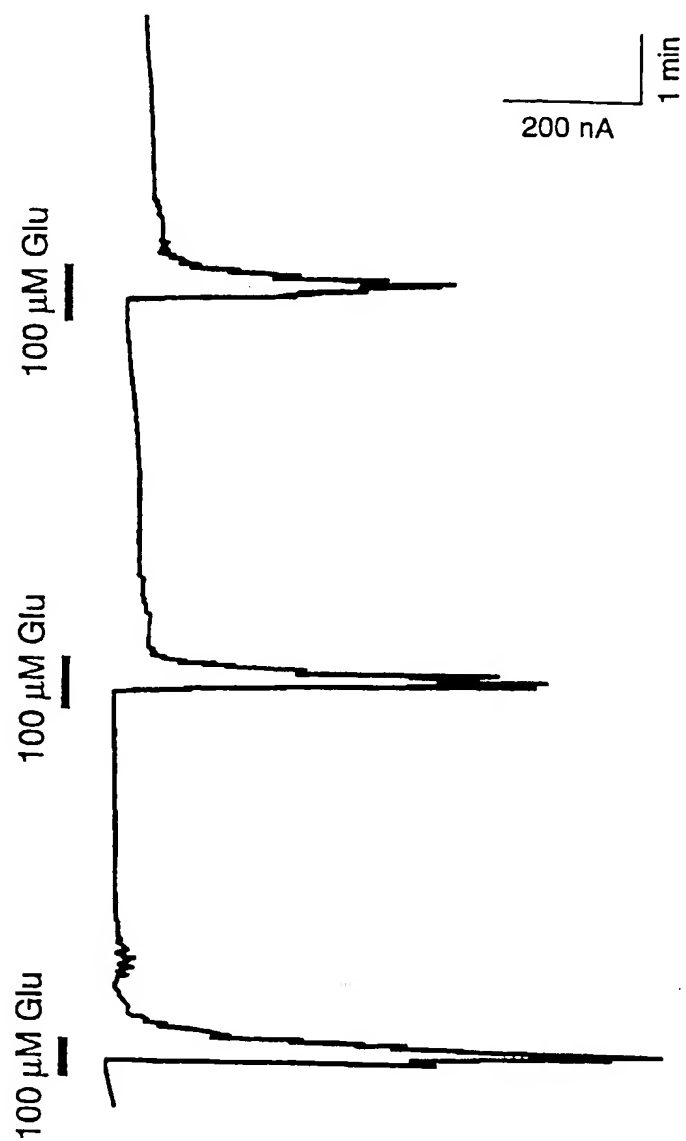
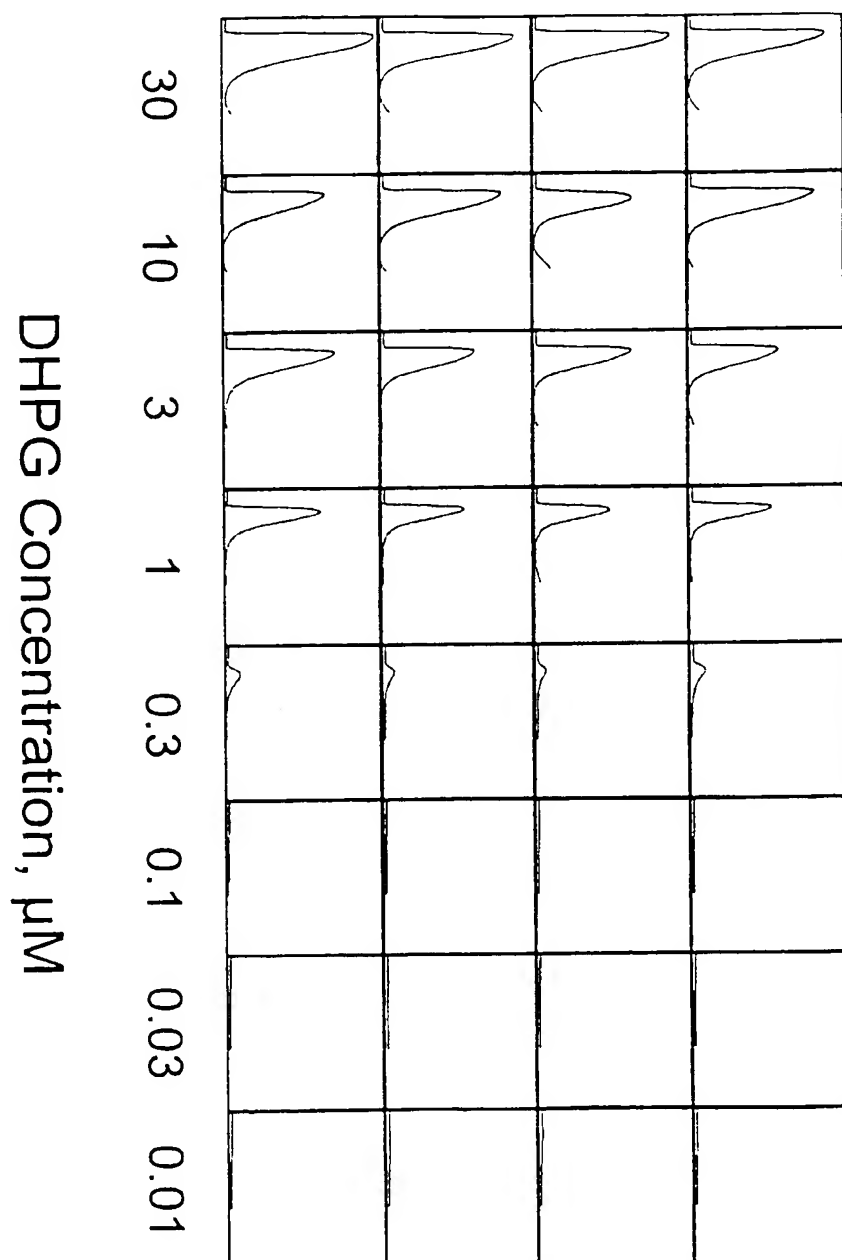


FIGURE 3

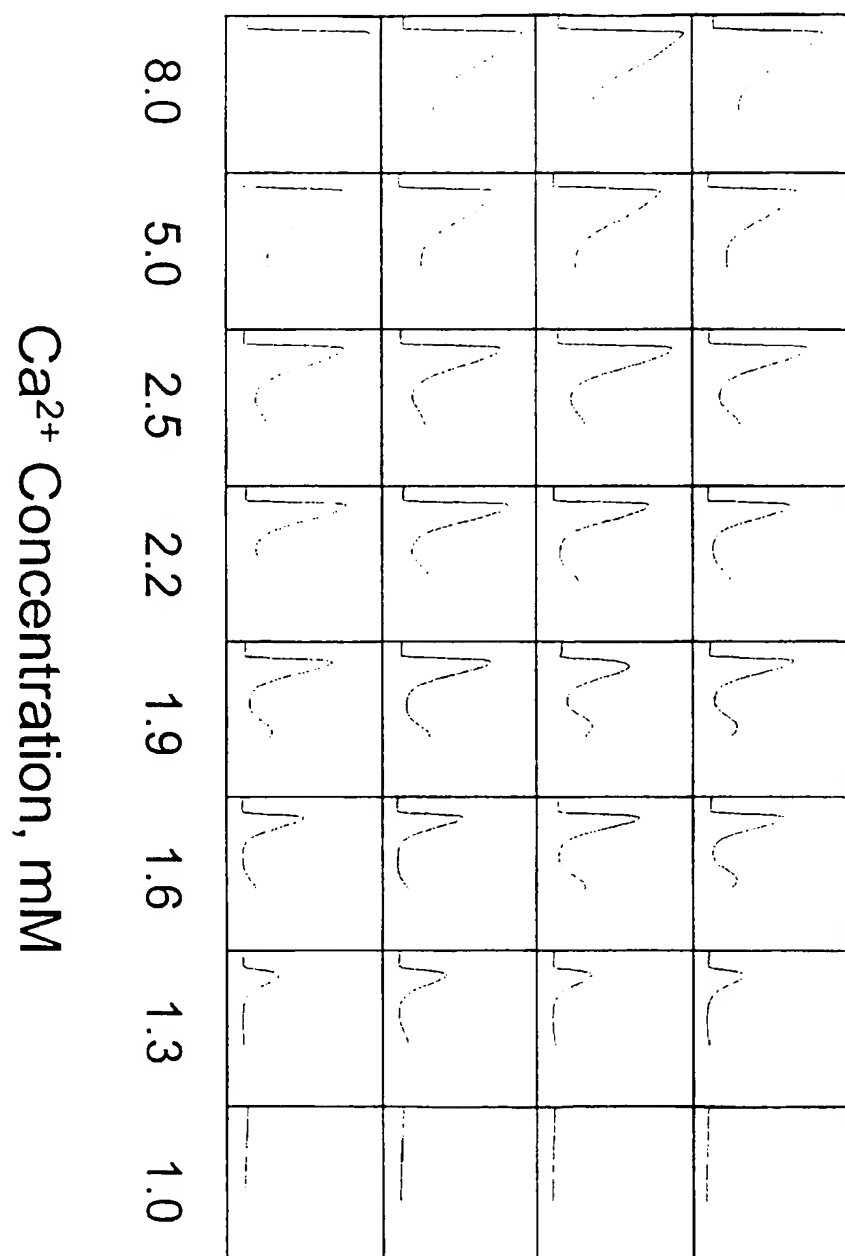
## Relative Fluorescence Intensity

Range = (-2000 to 54000 Units)



## Relative Fluorescence Intensity

Range = (-3000 to 31000 Units)



## SEQUENCE LISTING

&lt;110&gt; STORMANN, THOMAS M.

LEVINTHAL, CYNTHIA

STORJOHANN, LAURA

HAMMERLAND, LANCE G.

KRAPCHO, KAREN J.

NPS PHARMACEUTICALS, INC.

&lt;120&gt; A NOVEL HUMAN METABOTROPIC GLUTAMATE RECEPTOR

&lt;130&gt; 1094.2.6

&lt;140&gt;

&lt;141&gt;

&lt;150&gt; 60/161,481

&lt;151&gt; 1999-10-25

&lt;160&gt; 7

&lt;170&gt; PatentIn Ver. 2.1

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1

5

10

15

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20

25

30

ggg gac atc att att gga gct ctc ttt tct gtt cat cac cag cct act 144

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35

40

45

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50

55

60

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Asp Ser Cys Trp His Ser Ala Val Ala Leu Glu Gln Ser Ile Glu Phe
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Ile Arg Asp Ser Leu Ile Ser Ser Glu Glu Glu Glu Gly Leu Val Arg
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Cys Val Asp Gly Ser Ser Ser Ser Phe Arg Ser Lys Lys Pro Ile Val
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Gly Val Ile Gly Pro Gly Ser Ser Ser Val Ala Ile Gln Val Gln Asn
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Leu Leu Gln Leu Phe Asn Ile Pro Gln Ile Ala Tyr Ser Ala Thr Ser
165         170         175

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Met Asp Leu Ser Asp Lys Thr Leu Phe Lys Tyr Phe Met Arg Val Val
180         185         190

cct tca gat gct cag cag gca agg gcc atg gtg gac ata gtg aag agg 624
Pro Ser Asp Ala Gln Gln Ala Arg Ala Met Val Asp Ile Val Lys Arg
195         200         205

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785 790 795 800	
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<400> 2

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           20                          25                          30

Gly Asp Ile Ile Ile Gly Ala Leu Phe Ser Val His His Gln Pro Thr  
           35                          40                          45

Val Asp Lys Val His Glu Arg Lys Cys Gly Ala Val Arg Glu Gln Tyr  
           50                          55                          60

Gly Ile Gln Arg Val Glu Ala Met Leu His Thr Leu Glu Arg Ile Asn  
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 Asp Ser Cys Trp His Ser Ala Val Ala Leu Glu Gln Ser Ile Glu Phe  
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 Ile Arg Asp Ser Leu Ile Ser Ser Glu Glu Glu Glu Gly Leu Val Arg  
 115 120 125  
 Cys Val Asp Gly Ser Ser Ser Ser Phe Arg Ser Lys Lys Pro Ile Val  
 130 135 140  
 Gly Val Ile Gly Pro Gly Ser Ser Ser Val Ala Ile Gln Val Gln Asn  
 145 150 155 160  
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 165 170 175  
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 Pro Ser Asp Ala Gln Gln Ala Arg Ala Met Val Asp Ile Val Lys Arg  
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Leu Ala Gly Ser Lys Lys Lys Ile Cys Thr Lys Lys Pro Arg Phe Met  
 675 680 685

Ser Ala Cys Ala Gln Leu Val Ile Ala Phe Ile Leu Ile Cys Ile Gln  
 690 695 700

Leu Gly Ile Ile Val Ala Leu Phe Ile Met Glu Pro Pro Asp Ile Met  
 705 710 715 720

His Asp Tyr Pro Ser Ile Arg Glu Val Tyr Leu Ile Cys Asn Thr Thr  
 725 730 735

Asn Leu Gly Val Val Thr Pro Leu Gly Tyr Asn Gly Leu Leu Ile Leu  
 740 745 750

Ser Cys Thr Phe Tyr Ala Phe Lys Thr Arg Asn Val Pro Ala Asn Phe  
 755 760 765

Asn Glu Ala Lys Tyr Ile Ala Phe Thr Met Tyr Thr Thr Cys Ile Ile  
 770 775 780

Trp Leu Ala Phe Val Pro Ile Tyr Phe Gly Ser Asn Tyr Lys Ile Ile  
 785 790 795 800

Thr Met Cys Phe Ser Val Ser Leu Ser Ala Thr Val Ala Leu Gly Cys  
 805 810 815

Met Phe Val Pro Lys Val Tyr Ile Ile Leu Ala Lys Pro Glu Arg Asn  
 820 825 830

Val Arg Ser Ala Phe Thr Thr Ser Thr Val Val Arg Met His Val Gly  
835 840 845

Asp Gly Lys Ser Ser Ser Ala Ala Ser Arg Ser Ser Ser Leu Val Asn  
850 855 860

Leu Trp Lys Arg Arg Gly Ser Ser Gly Glu Thr Leu Arg Tyr Lys Asp  
865 870 875 880

Arg Arg Leu Ala Gln His Lys Ser Glu Ile Glu Cys Phe Thr Pro Pro  
885 890 895

Ser Pro Phe Arg Asp Ser Val Asp Ser Gly Ser Thr Thr Pro Asn Ser  
900 905 910

Pro Val Ser Glu Ser Ala Leu Cys Ile Pro Ser Ser Pro Lys Tyr Asp  
915 920 925

Thr Leu Ile Ile Arg Asp Tyr Thr Gln Ser Ser Ser Ser Leu  
930 935 940

<210> 3

<211> 2925

<212> DNA

<213> Artificial Sequence

<220>

<221> CDS

<222> (1) .. (2925)

<220>

<223> Description of Artificial Sequence:Chimeric  
molecule comprising portions of the human calcium  
receptor and human mGluR5d.

<400> 3

atg gca ttt tat agc tgc tgc tgg gtc ctc ttg gca ctc acc tgg cac 48  
Met Ala Phe Tyr Ser Cys Cys Trp Val Leu Leu Ala Leu Thr Trp His  
1 5 10 15

acc tct gcc tac ggg cca gac cag cga gcc caa aag aag ggg gac att 96  
Thr Ser Ala Tyr Gly Pro Asp Gln Arg Ala Gln Lys Lys Gly Asp Ile  
20 25 30

atc ctt ggg ggg ctc ttt cct att cat ttt gga gta gca gct aaa gat 144  
Ile Leu Gly Gly Leu Phe Pro Ile His Phe Gly Val Ala Ala Lys Asp



35	40	45	
caa gat ctc aaa tca agg ccg gag tct gtg gaa tgt atc agg tat aat			192
Gln Asp Leu Lys Ser Arg Pro Glu Ser Val Glu Cys Ile Arg Tyr Asn			
50	55	60	
ttc cgt ggg ttt cgc tgg tta cag gct atg ata ttt gcc ata gag gag			240
Phe Arg Gly Phe Arg Trp Leu Gln Ala Met Ile Phe Ala Ile Glu Glu			
65	70	75	80
ata aac agc agc cca gcc ctt ctt ccc aac ttg acg ctg gga tac agg			288
Ile Asn Ser Ser Pro Ala Leu Leu Pro Asn Leu Thr Leu Gly Tyr Arg			
85	90	95	
ata ttt gac act tgc aac acc gtt tct aag gcc ttg gaa gcc acc ctg			336
Ile Phe Asp Thr Cys Asn Thr Val Ser Lys Ala Leu Glu Ala Thr Leu			
100	105	110	
agt ttt gtt gct caa aac aaa att gat tct ttg aac ctt gat gag ttc			384
Ser Phe Val Ala Gln Asn Lys Ile Asp Ser Leu Asn Leu Asp Glu Phe			
115	120	125	
tgc aac tgc tca gag cac att ccc tct acg att gct gtg gtg gga gca			432
Cys Asn Cys Ser Glu His Ile Pro Ser Thr Ile Ala Val Val Gly Ala			
130	135	140	
act ggc tca ggc gtc tcc acg gca gtg gca aat ctg ctg ggg ctc ttc			480
Thr Gly Ser Gly Val Ser Thr Ala Val Ala Asn Leu Leu Gly Leu Phe			
145	150	155	160
tac att ccc cag gtc agt tat gcc tcc tcc agc aga ctc ctc agc aac			528
Tyr Ile Pro Gln Val Ser Tyr Ala Ser Ser Ser Arg Leu Leu Ser Asn			
165	170	175	
aag aat caa ttc aag tct ttc ctc cga acc atc ccc aat gat gag cac			576
Lys Asn Gln Phe Lys Ser Phe Leu Arg Thr Ile Pro Asn Asp Glu His			
180	185	190	
cag gcc act gcc atg gca gac atc atc gag tat ttc cgc tgg aac tgg			624
Gln Ala Thr Ala Met Ala Asp Ile Ile Glu Tyr Phe Arg Trp Asn Trp			
195	200	205	
gtg ggc aca att gca gct gat gac gac tat ggg cgg ccg ggg att gag			672
Val Gly Thr Ile Ala Ala Asp Asp Asp Tyr Gly Arg Pro Gly Ile Glu			
210	215	220	
aaa ttc cga gag gaa gct gag gaa agg gat atc tgc atc gac ttc agt			720
Lys Phe Arg Glu Glu Ala Glu Glu Arg Asp Ile Cys Ile Asp Phe Ser			

225	230	235	240	
gaa ctc atc tcc cag tac tct gat gag gaa gag atc cag cat gtg gta				768
Glu Leu Ile Ser Gln Tyr Ser Asp Glu Glu Glu Ile Gln His Val Val				
	245	250	255	
gag gtg att caa aat tcc acg gcc aaa gtc atc gtg gtt ttc tcc agt				816
Glu Val Ile Gln Asn Ser Thr Ala Lys Val Ile Val Val Phe Ser Ser				
	260	265	270	
ggc cca gat ctt gag ccc ctc atc aag gag att gtc cgg cgc aat atc				864
Gly Pro Asp Leu Glu Pro Leu Ile Lys Glu Ile Val Arg Arg Asn Ile				
	275	280	285	
acg ggc aag atc tgg ctg gcc agc gag gcc tgg gcc agc tcc tcc ctg				912
Thr Gly Lys Ile Trp Leu Ala Ser Glu Ala Trp Ala Ser Ser Ser Leu				
	290	295	300	
atc gcc atg cct cag tac ttc cac gtg gtt ggc ggc acc att gga ttc				960
Ile Ala Met Pro Gln Tyr Phe His Val Val Gly Gly Thr Ile Gly Phe				
	305	310	315	320
gct ctg aag gct ggg cag atc cca ggc ttc cgg gaa ttc ctg aag aag				1008
Ala Leu Lys Ala Gly Gln Ile Pro Gly Phe Arg Glu Phe Leu Lys Lys				
	325	330	335	
gtc cat ccc agg aag tct gtc cac aat ggt ttt gcc aag gag ttt tgg				1056
Val His Pro Arg Lys Ser Val His Asn Gly Phe Ala Lys Glu Phe Trp				
	340	345	350	
gaa gaa aca ttt aac tgc cac ctc caa gaa ggt gca aaa gga cct tta				1104
Glu Glu Thr Phe Asn Cys His Leu Gln Glu Gly Ala Lys Gly Pro Leu				
	355	360	365	
cct gtg gac acc ttt ctg aga ggt cac gaa gaa agt ggc gac agg ttt				1152
Pro Val Asp Thr Phe Leu Arg Gly His Glu Glu Ser Gly Asp Arg Phe				
	370	375	380	
agc aac agc tcg aca gcc ttc cga ccc ctc tgt aca ggg gat gag aac				1200
Ser Asn Ser Ser Thr Ala Phe Arg Pro Leu Cys Thr Gly Asp Glu Asn				
	385	390	395	400
atc agc agt gtc gag acc cct tac ata gat tac acg cat tta cgg ata				1248
Ile Ser Ser Val Glu Thr Pro Tyr Ile Asp Tyr Thr His Leu Arg Ile				
	405	410	415	
tcc tac aat gtg tac tta gca gtc tac tcc att gcc cac gcc ttg caa				1296
Ser Tyr Asn Val Tyr Leu Ala Val Tyr Ser Ile Ala His Ala Leu Gln				

420	425	430	
gat ata tat acc tgc tta cct ggg aga ggg ctc ttc acc aat ggc tcc			1344
Asp Ile Tyr Thr Cys Leu Pro Gly Arg Gly Leu Phe Thr Asn Gly Ser			
435	440	445	
tgt gca gac atc aag aaa gtt gag gcg tgg cag gtc ctg aag cac cta			1392
Cys Ala Asp Ile Lys Lys Val Glu Ala Trp Gln Val Leu Lys His Leu			
450	455	460	
cgg cat cta aac ttt aca aac aat atg ggg gag cag gtg acc ttt gat			1440
Arg His Leu Asn Phe Thr Asn Asn Met Gly Glu Gln Val Thr Phe Asp			
465	470	475	480
gag tgt ggt gac ctg gtg ggg aac tat tcc atc atc aac tgg cac ctc			1488
Glu Cys Gly Asp Leu Val Gly Asn Tyr Ser Ile Ile Asn Trp His Leu			
485	490	495	
tcc cca gag gat ggc tcc atc gtg ttt aag gaa gtc ggg tat tac aac			1536
Ser Pro Glu Asp Gly Ser Ile Val Phe Lys Glu Val Gly Tyr Tyr Asn			
500	505	510	
gtc tat gcc aag aag gga gaa aga ctc ttc atc aac gag gag aaa atc			1584
Val Tyr Ala Lys Lys Gly Glu Arg Leu Phe Ile Asn Glu Glu Lys Ile			
515	520	525	
ctg tgg agt ggg ttc tcc agg gag gtg ccc ttc tcc aac tgc agc cga			1632
Leu Trp Ser Gly Phe Ser Arg Glu Val Pro Phe Ser Asn Cys Ser Arg			
530	535	540	
gac tgc ctg gca ggg acc agg aaa ggg atc att gag ggg gag ccc acc			1680
Asp Cys Leu Ala Gly Thr Arg Lys Gly Ile Ile Glu Gly Glu Pro Thr			
545	550	555	560
tgc tgc ttt gag tgt gtg gag tgt cct gat ggg gag tat agt gat gag			1728
Cys Cys Phe Glu Cys Val Glu Cys Pro Asp Gly Glu Tyr Ser Asp Glu			
565	570	575	
aca gat gcc agt gcc tgt aac aag tgc cca gat gac ttc tgg tcc aat			1776
Thr Asp Ala Ser Ala Cys Asn Lys Cys Pro Asp Asp Phe Trp Ser Asn			
580	585	590	
gag aac cac acc tcc tgc gac ttg atc cca gta cag tat ctt cga tgg			1824
Glu Asn His Thr Ser Cys Asp Leu Ile Pro Val Gln Tyr Leu Arg Trp			
595	600	605	
ggg gac cct gaa ccc att gca gct gtg gtg ttt gcc tgc ctt ggc ctc			1872
Gly Asp Pro Glu Pro Ile Ala Ala Val Val Phe Ala Cys Leu Gly Leu			

610	615	620	
ctg gcc acc ctg ttt gtt act gta gtc ttc atc att tac cgt gat aca			1920
Leu Ala Thr Leu Phe Val Thr Val Val Phe Ile Ile Tyr Arg Asp Thr			
625	630	635	640
cca gta gtc aag tcc tca agc agg gaa ctc tgc tac att atc ctt gct			1968
Pro Val Val Lys Ser Ser Ser Arg Glu Leu Cys Tyr Ile Ile Leu Ala			
645	650	655	
ggc atc tgc ctg ggc tac tta tgt acc ttc tgc ctc att gcg aag ccc			2016
Gly Ile Cys Leu Gly Tyr Leu Cys Thr Phe Cys Leu Ile Ala Lys Pro			
660	665	670	
aaa cag att tac tgc tac ctt cag aga att ggc att ggt ctc tcc cca			2064
Lys Gln Ile Tyr Cys Tyr Leu Gln Arg Ile Gly Ile Gly Leu Ser Pro			
675	680	685	
gcc atg agc tac tca gcc ctt gta aca aag acc aac cgt att gca agg			2112
Ala Met Ser Tyr Ser Ala Leu Val Thr Lys Thr Asn Arg Ile Ala Arg			
690	695	700	
atc ctg gct ggc agc aag aag aag atc tgt acc aaa aag ccc aga ttc			2160
Ile Leu Ala Gly Ser Lys Lys Lys Ile Cys Thr Lys Lys Pro Arg Phe			
705	710	715	720
atg agt gcc tgt gcc cag cta gtg att gct ttc att ctc ata tgc atc			2208
Met Ser Ala Cys Ala Gln Leu Val Ile Ala Phe Ile Leu Ile Cys Ile			
725	730	735	
cag ttg ggc atc atc gtt gcc ctc ttt ata atg gag cct cct gac ata			2256
Gln Leu Gly Ile Ile Val Ala Leu Phe Ile Met Glu Pro Pro Asp Ile			
740	745	750	
atg cat gac tac cca agc att cga gaa gtc tac ctg atc tgt aac acc			2304
Met His Asp Tyr Pro Ser Ile Arg Glu Val Tyr Leu Ile Cys Asn Thr			
755	760	765	
acc aac cta gga gtt gtc act cca ctt gga tac aat gga ttg ttg att			2352
Thr Asn Leu Gly Val Val Thr Pro Leu Gly Tyr Asn Gly Leu Leu Ile			
770	775	780	
ttg agc tgc acc ttc tat gcg ttc aag acc aga aat gtt cca gct aac			2400
Leu Ser Cys Thr Phe Tyr Ala Phe Lys Thr Arg Asn Val Pro Ala Asn			
785	790	795	800
ttc aac gag gcc aag tat atc gcc ttc aca atg tac acg acc tgc att			2448
Phe Asn Glu Ala Lys Tyr Ile Ala Phe Thr Met Tyr Thr Thr Cys Ile			

805	810	815	
ata tgg cta gct ttt gtg cca atc tac ttt ggc agc aac tac aaa atc			2496
Ile Trp Leu Ala Phe Val Pro Ile Tyr Phe Gly Ser Asn Tyr Lys Ile			
820	825	830	
atc acc atg tgt ttc tcg gtc agc ctc agt gcc aca gtg gcc cta ggc			2544
Ile Thr Met Cys Phe Ser Val Ser Leu Ser Ala Thr Val Ala Leu Gly			
835	840	845	
tgc atg ttt gtg ccg aag gtg tac atc atc ctg gcc aaa cca gag aga			2592
Cys Met Phe Val Pro Lys Val Tyr Ile Ile Leu Ala Lys Pro Glu Arg			
850	855	860	
aac gtg cgc agc gcc ttc acc aca tct acc gtg gtg cgc atg cat gta			2640
Asn Val Arg Ser Ala Phe Thr Thr Ser Thr Val Val Arg Met His Val			
865	870	875	880
ggg gat ggc aag tca tcc tcc gca gcc agc aga tcc agc agc cta gtc			2688
Gly Asp Gly Lys Ser Ser Ser Ala Ala Ser Arg Ser Ser Ser Leu Val			
885	890	895	
aac ctg tgg aag aga agg ggc tcc tct ggg gaa acc tta agg tac aaa			2736
Asn Leu Trp Lys Arg Arg Gly Ser Ser Gly Glu Thr Leu Arg Tyr Lys			
900	905	910	
gac agg aga ctg gcc cag cac aag tcg gaa ata gag tgt ttc acc ccg			2784
Asp Arg Arg Leu Ala Gln His Lys Ser Glu Ile Glu Cys Phe Thr Pro			
915	920	925	
ccg tcc ccc ttc aga gac tcg gtg gac tcg ggg agc aca acc ccc aac			2832
Pro Ser Pro Phe Arg Asp Ser Val Asp Ser Gly Ser Thr Thr Pro Asn			
930	935	940	
tcg cca gtg tcc gag tcg gcc ctc tgt atc ccg tcg tct ccc aaa tat			2880
Ser Pro Val Ser Glu Ser Ala Leu Cys Ile Pro Ser Ser Pro Lys Tyr			
945	950	955	960
gac act ctt atc ata aga gat tac act cag agc tcc tcg tcg ttg			2925
Asp Thr Leu Ile Ile Arg Asp Tyr Thr Gln Ser Ser Ser Ser Leu			
965	970	975	

&lt;210&gt; 4

&lt;211&gt; 975

&lt;212&gt; PRT

&lt;213&gt; Artificial Sequence

&lt;223&gt; Description of Artificial Sequence:Chimeric

molecule comprising portions of the human calcium  
receptor and human mGluR5d.

<400> 4

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Met Ala Phe Tyr Ser Cys Cys Trp Val Leu Leu Ala Leu Thr Trp His
 1             5             10             15

Thr Ser Ala Tyr Gly Pro Asp Gln Arg Ala Gln Lys Lys Gly Asp Ile
      20             25             30

Ile Leu Gly Gly Leu Phe Pro Ile His Phe Gly Val Ala Ala Lys Asp
      35             40             45

Gln Asp Leu Lys Ser Arg Pro Glu Ser Val Glu Cys Ile Arg Tyr Asn
      50             55             60

Phe Arg Gly Phe Arg Trp Leu Gln Ala Met Ile Phe Ala Ile Glu Glu
      65             70             75             80

Ile Asn Ser Ser Pro Ala Leu Leu Pro Asn Leu Thr Leu Gly Tyr Arg
      85             90             95

Ile Phe Asp Thr Cys Asn Thr Val Ser Lys Ala Leu Glu Ala Thr Leu
      100            105            110

Ser Phe Val Ala Gln Asn Lys Ile Asp Ser Leu Asn Leu Asp Glu Phe
      115            120            125

Cys Asn Cys Ser Glu His Ile Pro Ser Thr Ile Ala Val Val Gly Ala
      130            135            140

Thr Gly Ser Gly Val Ser Thr Ala Val Ala Asn Leu Leu Gly Leu Phe
      145            150            155            160

Tyr Ile Pro Gln Val Ser Tyr Ala Ser Ser Ser Arg Leu Leu Ser Asn
      165            170            175

Lys Asn Gln Phe Lys Ser Phe Leu Arg Thr Ile Pro Asn Asp Glu His
      180            185            190

Gln Ala Thr Ala Met Ala Asp Ile Ile Glu Tyr Phe Arg Trp Asn Trp
      195            200            205

Val Gly Thr Ile Ala Ala Asp Asp Asp Tyr Gly Arg Pro Gly Ile Glu
      210            215            220

Lys Phe Arg Glu Glu Ala Glu Glu Arg Asp Ile Cys Ile Asp Phe Ser
      225            230            235            240

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Glu Leu Ile Ser Gln Tyr Ser Asp Glu Glu Glu Ile Gln His Val Val  
 245 250 255

Glu Val Ile Gln Asn Ser Thr Ala Lys Val Ile Val Val Phe Ser Ser  
 260 265 270

Gly Pro Asp Leu Glu Pro Leu Ile Lys Glu Ile Val Arg Arg Asn Ile  
 275 280 285

Thr Gly Lys Ile Trp Leu Ala Ser Glu Ala Trp Ala Ser Ser Ser Leu  
 290 295 300

Ile Ala Met Pro Gln Tyr Phe His Val Val Gly Gly Thr Ile Gly Phe  
 305 310 315 320

Ala Leu Lys Ala Gly Gln Ile Pro Gly Phe Arg Glu Phe Leu Lys Lys  
 325 330 335

Val His Pro Arg Lys Ser Val His Asn Gly Phe Ala Lys Glu Phe Trp  
 340 345 350

Glu Glu Thr Phe Asn Cys His Leu Gln Glu Gly Ala Lys Gly Pro Leu  
 355 360 365

Pro Val Asp Thr Phe Leu Arg Gly His Glu Glu Ser Gly Asp Arg Phe  
 370 375 380

Ser Asn Ser Ser Thr Ala Phe Arg Pro Leu Cys Thr Gly Asp Glu Asn  
 385 390 395 400

Ile Ser Ser Val Glu Thr Pro Tyr Ile Asp Tyr Thr His Leu Arg Ile  
 405 410 415

Ser Tyr Asn Val Tyr Leu Ala Val Tyr Ser Ile Ala His Ala Leu Gln  
 420 425 430

Asp Ile Tyr Thr Cys Leu Pro Gly Arg Gly Leu Phe Thr Asn Gly Ser  
 435 440 445

Cys Ala Asp Ile Lys Lys Val Glu Ala Trp Gln Val Leu Lys His Leu  
 450 455 460

Arg His Leu Asn Phe Thr Asn Asn Met Gly Glu Gln Val Thr Phe Asp  
 465 470 475 480

Glu Cys Gly Asp Leu Val Gly Asn Tyr Ser Ile Ile Asn Trp His Leu  
 485 490 495

Ser Pro Glu Asp Gly Ser Ile Val Phe Lys Glu Val Gly Tyr Tyr Asn  
                   500                  505                  510

Val Tyr Ala Lys Lys Gly Glu Arg Leu Phe Ile Asn Glu Glu Lys Ile  
                   515                  520                  525

Leu Trp Ser Gly Phe Ser Arg Glu Val Pro Phe Ser Asn Cys Ser Arg  
                   530                  535                  540

Asp Cys Leu Ala Gly Thr Arg Lys Gly Ile Ile Glu Gly Glu Pro Thr  
 545                  550                  555                  560

Cys Cys Phe Glu Cys Val Glu Cys Pro Asp Gly Glu Tyr Ser Asp Glu  
                   565                  570                  575

Thr Asp Ala Ser Ala Cys Asn Lys Cys Pro Asp Asp Phe Trp Ser Asn  
                   580                  585                  590

Glu Asn His Thr Ser Cys Asp Leu Ile Pro Val Gln Tyr Leu Arg Trp  
                   595                  600                  605

Gly Asp Pro Glu Pro Ile Ala Ala Val Val Phe Ala Cys Leu Gly Leu  
                   610                  615                  620

Leu Ala Thr Leu Phe Val Thr Val Val Phe Ile Ile Tyr Arg Asp Thr  
 625                  630                  635                  640

Pro Val Val Lys Ser Ser Ser Arg Glu Leu Cys Tyr Ile Ile Leu Ala  
                   645                  650                  655

Gly Ile Cys Leu Gly Tyr Leu Cys Thr Phe Cys Leu Ile Ala Lys Pro  
                   660                  665                  670

Lys Gln Ile Tyr Cys Tyr Leu Gln Arg Ile Gly Ile Gly Leu Ser Pro  
                   675                  680                  685

Ala Met Ser Tyr Ser Ala Leu Val Thr Lys Thr Asn Arg Ile Ala Arg  
                   690                  695                  700

Ile Leu Ala Gly Ser Lys Lys Lys Ile Cys Thr Lys Lys Pro Arg Phe  
 705                  710                  715                  720

Met Ser Ala Cys Ala Gln Leu Val Ile Ala Phe Ile Leu Ile Cys Ile  
                   725                  730                  735

Gln Leu Gly Ile Ile Val Ala Leu Phe Ile Met Glu Pro Pro Asp Ile  
                   740                  745                  750



Met His Asp Tyr Pro Ser Ile Arg Glu Val Tyr Leu Ile Cys Asn Thr  
 755 760 765  
 Thr Asn Leu Gly Val Val Thr Pro Leu Gly Tyr Asn Gly Leu Leu Ile  
 770 775 780  
 Leu Ser Cys Thr Phe Tyr Ala Phe Lys Thr Arg Asn Val Pro Ala Asn  
 785 790 795 800  
 Phe Asn Glu Ala Lys Tyr Ile Ala Phe Thr Met Tyr Thr Thr Cys Ile  
 805 810 815  
 Ile Trp Leu Ala Phe Val Pro Ile Tyr Phe Gly Ser Asn Tyr Lys Ile  
 820 825 830  
 Ile Thr Met Cys Phe Ser Val Ser Leu Ser Ala Thr Val Ala Leu Gly  
 835 840 845  
 Cys Met Phe Val Pro Lys Val Tyr Ile Ile Leu Ala Lys Pro Glu Arg  
 850 855 860  
 Asn Val Arg Ser Ala Phe Thr Thr Ser Thr Val Val Arg Met His Val  
 865 870 875 880  
 Gly Asp Gly Lys Ser Ser Ser Ala Ala Ser Arg Ser Ser Ser Leu Val  
 885 890 895  
 Asn Leu Trp Lys Arg Arg Gly Ser Ser Gly Glu Thr Leu Arg Tyr Lys  
 900 905 910  
 Asp Arg Arg Leu Ala Gln His Lys Ser Glu Ile Glu Cys Phe Thr Pro  
 915 920 925  
 Pro Ser Pro Phe Arg Asp Ser Val Asp Ser Gly Ser Thr Thr Pro Asn  
 930 935 940  
 Ser Pro Val Ser Glu Ser Ala Leu Cys Ile Pro Ser Ser Pro Lys Tyr  
 945 950 955 960  
 Asp Thr Leu Ile Ile Arg Asp Tyr Thr Gln Ser Ser Ser Ser Leu  
 965 970 975

&lt;210&gt; 5

&lt;211&gt; 3129

&lt;212&gt; DNA

<213> Artificial Sequence

<220>

<223> Description of Artificial Sequence:Chimeric molecule comprising portions of human mGluR5d and the human calcium receptor.

<220>

<221> CDS

<222> () .. (3129)

<400> 5

atg gtc ctt ctg ttg atc ctg tca gtc tta ctt ttg aaa gaa gat gtc	48
Met Val Leu Leu Leu Ile Leu Ser Val Leu Leu Leu Lys Glu Asp Val	
1 5 10 15	
cgt ggg agt gca cag tcc agt gag agg agg gtg gtg gct cac atg ccg	96
Arg Gly Ser Ala Gln Ser Ser Glu Arg Arg Val Val Ala His Met Pro	
20 25 30	
ggt gac atc att att gga gct ctc ttt tct gtt cat cac cag cct act	144
Gly Asp Ile Ile Ile Gly Ala Leu Phe Ser Val His His Gln Pro Thr	
35 40 45	
gtg gac aaa gtt cat gag agg aag tgt ggg gcg gtc cgt gaa cag tat	192
Val Asp Lys Val His Glu Arg Lys Cys Gly Ala Val Arg Glu Gln Tyr	
50 55 60	
ggc att cag aga gtg gag gcc atg ctg cat acc ctg gaa agg atc aat	240
Gly Ile Gln Arg Val Glu Ala Met Leu His Thr Leu Glu Arg Ile Asn	
65 70 75 80	
tca gac ccc aca ctc ttg ccc aac atc aca ctg ggc tgt gag ata agg	288
Ser Asp Pro Thr Leu Leu Pro Asn Ile Thr Leu Gly Cys Glu Ile Arg	
85 90 95	
gac tcc tgc tgg cat tcg gct gtg gcc cta gag cag agc att gag ttc	336
Asp Ser Cys Trp His Ser Ala Val Ala Leu Glu Gln Ser Ile Glu Phe	
100 105 110	
ata aga gat tcc ctc att tct tca gaa gag gaa gaa ggc ttg gta cgc	384
Ile Arg Asp Ser Leu Ile Ser Ser Glu Glu Glu Glu Gly Leu Val Arg	
115 120 125	
tgt gtg gat ggc tcc tcc tct tcc ttc cgc tcc aag aag ccc ata gta	432
Cys Val Asp Gly Ser Ser Ser Ser Phe Arg Ser Lys Lys Pro Ile Val	
130 135 140	

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ggg gtc att ggg cct ggc tcc agt tct gta gcc att cag gtc cag aat 480
Gly Val Ile Gly Pro Gly Ser Ser Ser Val Ala Ile Gln Val Gln Asn
145                150                155                160

ttg ctc cag ctt ttc aac ata cct cag att gct tac tca gca acc agc 528
Leu Leu Gln Leu Phe Asn Ile Pro Gln Ile Ala Tyr Ser Ala Thr Ser
                165                170                175

atg gat ctg agt gac aag act ctg ttc aaa tat ttc atg agg gtt gtg 576
Met Asp Leu Ser Asp Lys Thr Leu Phe Lys Tyr Phe Met Arg Val Val
                180                185                190

cct tca gat gct cag cag gca agg gcc atg gtg gac ata gtg aag agg 624
Pro Ser Asp Ala Gln Gln Ala Arg Ala Met Val Asp Ile Val Lys Arg
                195                200                205

tac aac tgg acc tat gta tca gcc gtg cac aca gaa ggc aac tat gga 672
Tyr Asn Trp Thr Tyr Val Ser Ala Val His Thr Glu Gly Asn Tyr Gly
                210                215                220

gaa agt ggg atg gaa gcc ttc aaa gat atg tca gcg aag gaa ggg att 720
Glu Ser Gly Met Glu Ala Phe Lys Asp Met Ser Ala Lys Glu Gly Ile
225                230                235                240

tgc atc gcc cac tct tac aaa atc tac agt aat gca ggg gag cag agc 768
Cys Ile Ala His Ser Tyr Lys Ile Tyr Ser Asn Ala Gly Glu Gln Ser
                245                250                255

ttt gat aag ctg ctg aag aag ctc aca agt cac ttg ccc aag gcc cgg 816
Phe Asp Lys Leu Leu Lys Lys Leu Thr Ser His Leu Pro Lys Ala Arg
                260                265                270

gtg gtg gcc tgc ttc tgt gag ggc atg acg gtg aga ggt ctg ctg atg 864
Val Val Ala Cys Phe Cys Glu Gly Met Thr Val Arg Gly Leu Leu Met
                275                280                285

gcc atg agg cgc ctg ggt cta gcg gga gaa ttt ctg ctt ctg ggc agt 912
Ala Met Arg Arg Leu Gly Leu Ala Gly Glu Phe Leu Leu Leu Gly Ser
                290                295                300

gat ggc tgg gct gac agg tat gat gtg aca gat gga tat cag cga gaa 960
Asp Gly Trp Ala Asp Arg Tyr Asp Val Thr Asp Gly Tyr Gln Arg Glu
305                310                315                320

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ctg acc ctc cca cag cag caa cga tct cag cag cag ccc aga tgc aag 2784  
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 915 920 925

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&lt;211&gt; 1043

&lt;212&gt; PRT

&lt;213&gt; Artificial Sequence

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 molecule comprising portions of human mGluR5d and  
 the human calcium receptor.

&lt;400&gt; 6

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 Gly Ile Gln Arg Val Glu Ala Met Leu His Thr Leu Glu Arg Ile Asn  
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 Ser Asp Pro Thr Leu Leu Pro Asn Ile Thr Leu Gly Cys Glu Ile Arg  
 85 90 95  
 Asp Ser Cys Trp His Ser Ala Val Ala Leu Glu Gln Ser Ile Glu Phe  
 100 105 110  
 Ile Arg Asp Ser Leu Ile Ser Ser Glu Glu Glu Glu Gly Leu Val Arg  
 115 120 125  
 Cys Val Asp Gly Ser Ser Ser Ser Phe Arg Ser Lys Lys Pro Ile Val  
 130 135 140  
 Gly Val Ile Gly Pro Gly Ser Ser Ser Val Ala Ile Gln Val Gln Asn  
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 225 230 235 240  
 Cys Ile Ala His Ser Tyr Lys Ile Tyr Ser Asn Ala Gly Glu Gln Ser  
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 Phe Asp Lys Leu Leu Lys Lys Leu Thr Ser His Leu Pro Lys Ala Arg  
 260 265 270



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His Asp Tyr Pro Ser Ile Arg Glu Val Tyr Leu Ile Cys Asn Thr Thr  
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Asn Leu Gly Val Val Thr Pro Leu Gly Tyr Asn Gly Leu Leu Ile Leu  
 740 745 750

Ser Cys Thr Phe Tyr Ala Phe Lys Thr Arg Asn Val Pro Ala Asn Phe  
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Asn Glu Ala Lys Tyr Ile Ala Phe Thr Met Tyr Thr Thr Cys Ile Ile  
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Trp Leu Ala Phe Val Pro Ile Tyr Phe Gly Ser Asn Tyr Lys Ile Ile  
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Gln Lys Val Ile Phe Gly Ser Gly Thr Val Thr Phe Ser Leu Ser Phe  
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<210> 7

<211> 1212

<212> PRT

<213> Homo sapiens

<400> 7

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Val Asp Lys Val His Glu Arg Lys Cys Gly Ala Val Arg Glu Gln Tyr  
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Ile Arg Asp Ser Leu Ile Ser Ser Glu Glu Glu Glu Gly Leu Val Arg  
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Asp Leu Thr Gly Cys Asp Leu Ile Pro Val Gln Tyr Leu Arg Trp Gly		
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	580	585 590
Ala Thr Leu Phe Val Thr Val Val Phe Ile Ile Tyr Arg Asp Thr Pro		
	595	600 605
Val Val Lys Ser Ser Ser Arg Glu Leu Cys Tyr Ile Ile Leu Ala Gly		
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Ile Cys Leu Gly Tyr Leu Cys Thr Phe Cys Leu Ile Ala Lys Pro Lys		
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Gln Ile Tyr Cys Tyr Leu Gln Arg Ile Gly Ile Gly Leu Ser Pro Ala		
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	660	665 670
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Ser Cys Thr Phe Tyr Ala Phe Lys Thr Arg Asn Val Pro Ala Asn Phe						
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Phe Arg Asp Ser Val Asp Ser Gly Ser Thr Thr Pro Asn Ser Pro Val		
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Ser Glu Ser Ala Leu Cys Ile Pro Ser Ser Pro Lys Tyr Asp Thr Leu		
1185	1190	1195
1200		
Ile Ile Arg Asp Tyr Thr Gln Ser Ser Ser Ser Leu		
1205	1210	



## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US00/29356

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) : Please See Extra Sheet.

US CL : 435/7.2, 69.1, 320.1, 325; 530/350; 536/23.5

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 435/7.2, 69.1, 320.1, 325; 530/350; 536/23.5

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- A	WO 94/29449 A1 (THE SALK INSTITUTE BIOTECHNOLOGY/ INDUSTRIAL ASSOCIATES, INC.) 22 December 1994, pages 99- 103.	1 ----- 2-30
X ----- A	WO 99/38975 A2 (JOHNSON et al.) 05 August 1999, figure 17.	1 ----- 2-30



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
*A* document defining the general state of the art which is not considered to be of particular relevance	*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
*E* earlier document published on or after the international filing date	*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*Z* document member of the same patent family
*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

07 DECEMBER 2000

Date of mailing of the international search report

12 JAN 2001

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
Box PCT  
Washington, D.C. 20231

Facsimile No. (703) 305-3230

Authorized officer

MICHAEL PAK

Telephone No. (703) 308-0156

DELLA MAE COLLINS  
PARALEGAL SPECIALIST  
TECHNOLOGY CENTER 1600

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US00/29356

## A. CLASSIFICATION OF SUBJECT MATTER:

IPC (7):

C07K 14/435, 14/705; C12N 5/10, 15/09, 15/12, 15/63; G01N 33/53

## B. FIELDS SEARCHED

Electronic data bases consulted (Name of data base and where practicable terms used):

BRS, STN, MEDLINE, GENESEQ, PIR, SWISS-PROT

search terms: metabotropic glutamate receptor, seven transmembrane receptor